THE Petroleum Engineer

MIDYEAR 1935

VOLUME VI NUMBER IX

A MAGAZINE OF METHODS FOR OPERATING MEN

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DRILLING AND PRODUCTION

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EDITORIAL

A Constructive Program of Principles

ABOLISHMENT of the legal enforcement of NRA codes for industry as a result of the decision of the United States Supreme Court on Monday, May 27, may bring about a change in the political views held with regard to pending legislation that seeks federal control of the petroleum industry. It should not, however, be cause for making any important changes in the constructive program of principles so clearly and frankly set forth in the petition to Congress unanimously adopted May 3, by the directors of the American Petroleum Institute in meeting at Chicago.

From a reading of these principles it is plain that they are in the public's, as well as the industry's, interest. They are based on the valuable experience obtained and the still more valuable lessons learned during the time the petroleum code was in effect. An impartial study will show that the gains made during this period were due to voluntary cooperation, aided by economic pressure, rather than to any federal edict.

Now there arises the question of whether, in view of the Sherman anti-trust law being in full force again now the code has been invalidated, there will be the same freedom of voluntary cooperative action permitted within the industry, even though such freedom of action is in the public's interest. On this question must hinge whatever cooperative action, if any, the petroleum industry may deem desirable or be forced to take on its own behalf at this time.

In order to preserve the desirable features of the code and also to prevent a possible reversion to destructive operating practices that might again plunge the industry into chaos, the program of principles as laid out in the A.P.I. petition to Congress could well be adopted by the industry as a basis for the formulation of a code under which it might operate and which would be in keeping with its own and the public's interest. It is here urged that some such action in regard to a working code be speedily taken by the industry. By so doing it will consolidate the business gains already made toward recovery and a more permanent stabilization—and will do much toward warding off the enactment of harmful government legislation to control the petroleum industry.

Conservation of petroleum, under the cloak of which so much legislation for control of the industry is proposed, is not just a matter of keeping oil in the ground; true conservation is a matter of obtaining the greatest ultimate yield of petroleum from a reservoir at the least possible cost and of its efficient utilization after it is produced. It is to bring about this type of conservation that the technical men in the industry are devoting their energies.

Too well does the industry recognize that the basic difficulty in the production of crude petroleum is the rule of capture. In the early days, little was really known of underground reservoirs and consequently, under a misapprehension, the rule of capture was imposed by the courts. Technical progress is now correcting this early interpretation of the law.

Wells and pools are now prorated in accordance with their capacity to produce. Sounder and more equitable methods of proration are being evolved. Legislative aid has been sought and received in the oil-producing states toward this end. The need for equitable proration in flush fields, although recognized when the Seminole pool was developed, and later in the development of the Oklahoma City field, reached a head when the Oklahoma City field came in.

Bottom-hole pressure, reservoir energy, sand thickness, and other subsurface physical conditions are gradually becoming to be recognized as the governing factors by means of which the production of oil should be controlled. The benefit to the producer (and also to the consumer) of producing oil in accordance with the natural conditions in the reservoir is now generally recognized. The harmful results that eventually will be felt by developing and producing a field during its flush stage of production without regard to reservoir conditions, are particularly emphasized in deep fields. One such example is the Oklahoma City pool. Because of the flagrant dissipation of reservoir energy in the early development of this pool, lifting costs are rapidly nearing the point where it will be commercially unprofitable to produce some wells by ordinary methods.

As against this condition, there are other fields where strict control has been exercised; notably the Yates, Van, Sugarland, and Conroe fields in Texas. In these fields the benefits of intelligent control and application of the principle of developing and producing pools on the basis of their reservoir energy, have been amply demonstrated.

Technique in analyzing reservoir conditions and engineering knowledge have now reached the stage that the flowing life of a pool can be determined for different rates of production. Being able to do this means that an operator can plan in advance a development and production program that will result in complying with true conservation requirements, enabling him to reap the greatest profit from his operations.

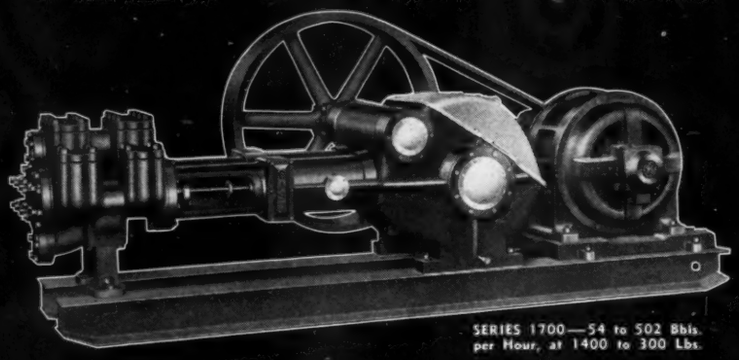
Utilization of the reservoir energy to the greatest advantage may be enforced by state authority, especially when the evidence is available that reservoir energy is being dissipated by wasteful field practices. The leading oil-producing states now have regulations in force. Such enlightened methods of proration are complied with more readily by operators than formerly, and has reduced the necessity for drastic compulsory measures of enforcement.

It is the rapidly-growing recognition of sound practices by the operator that has brightened the outlook for greater voluntary cooperation within the industry than it has ever known before. Enforcement of good field practice is today not the problem it once was, despite those well-meaning critics who would foist full federal control on the petroleum industry on the assumption that destructive competitive production practices are still rampant.

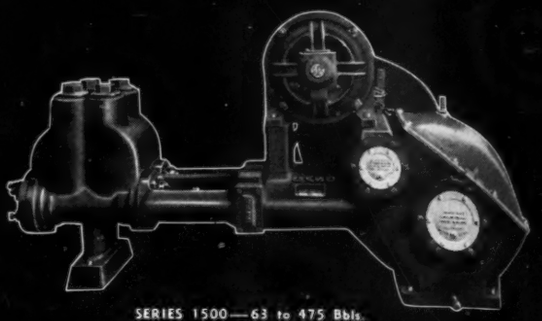
More than ninety per cent of the petroleum industry is convinced that federal control is unnecessary and unwise. It would serve to dull incentive and healthy competition and hamper progress. From healthy competition, which is the very life of business, the public is always the greatest beneficiary.

Permanent stabilization of the oil business should be founded on voluntary cooperative effort within the industry. The constructive program of policies outlined in the petition to Congress by the directors of the American Petroleum Institute, provides a sound guide to future action in fostering such voluntary cooperative effort.

PUMPS DESIGNED STRICTLY FOR THE OIL INDUSTRY



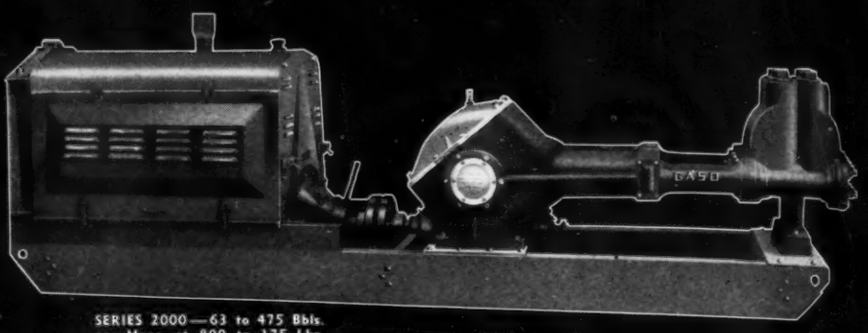
SERIES 1700—54 to 502 Bbls. per Hour, at 1400 to 300 Lbs.



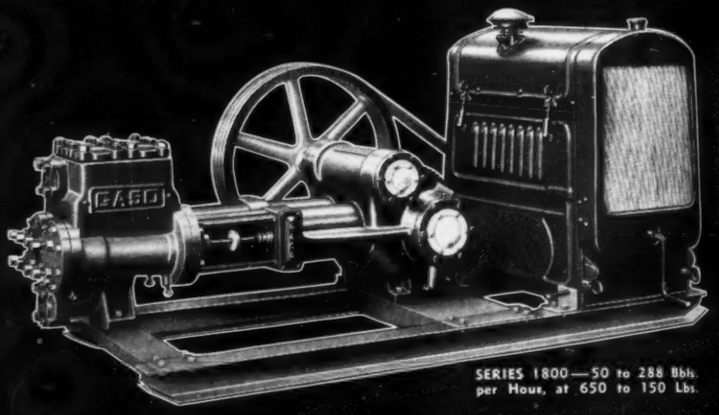
SERIES 1500—63 to 475 Bbls. per Hour, at 800 to 175 Lbs.

FIG. 601 — Walking Beam Pump, 30 to 55 Bbls. per Hour

FIG. 604 — For Gas or Vacuum, 26 to 28 Points Vacuum, 14" to 20" Cyl.



SERIES 2000—63 to 475 Bbls. per Hour, at 800 to 175 Lbs.



SERIES 1800—50 to 288 Bbls. per Hour, at 650 to 150 Lbs.

Every Gaso Pump measures up to strictly maintained standards of excellence.

And you'll find Gaso *service* prompt and reliable—matching Gaso Pumps in dependability.

GASO PUMP & BURNER MFG. COMPANY

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FIG. 201 — Rodline Pump, 31 to 41 Bbls. per Hour

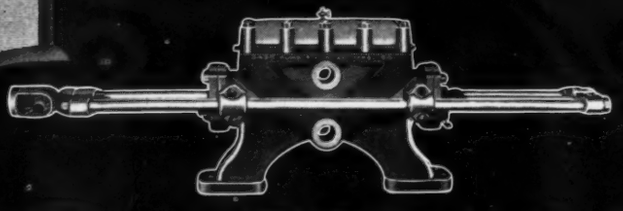
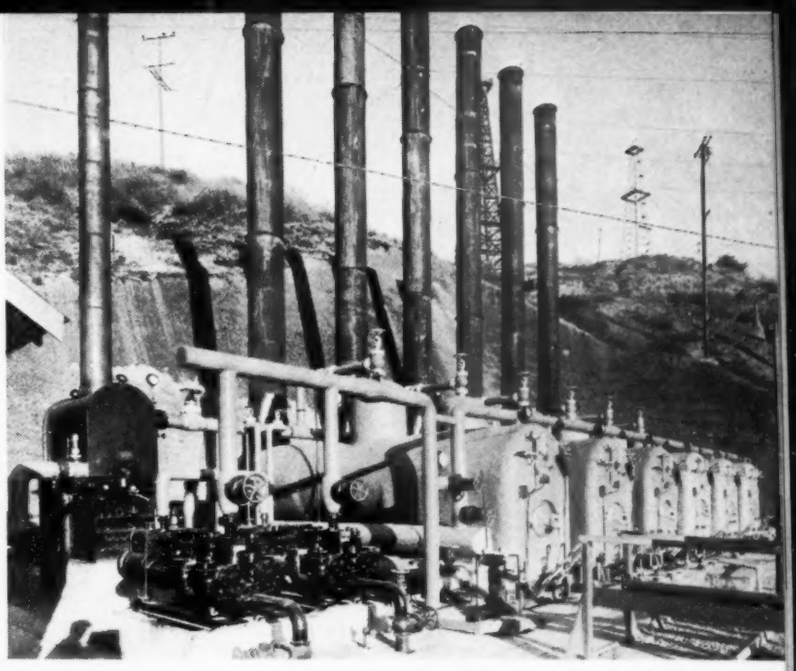


FIG. 301 — Jerker Pump, 32 to 157 Bbls. per Hour

GASO PUMPS

for every oil industry need



Installation of boilers with Foster-Wheeler superheater, Ventura Avenue field, California.

By

K. C. SCLATER

Progress and Trends in Drilling Practice

DRILLING and wildcatting operations have increased greatly during the past year, and the indications are that they will continue to be quite active for some time to come. A lack of major discoveries, coupled with the conservative development of newly discovered pools, has acted as an incentive for the expansion of wildcatting operations.

Although drilling has increased in volume, close attention is being paid to drilling costs. Efforts made to effect economies wherever possible are reflected in the trend toward designing drilling equipment so that rigging-up can be expedited and costs thereby reduced. Drilling equipment of the heaviest type is being unitized in order to increase its portability and save time in setting-up.

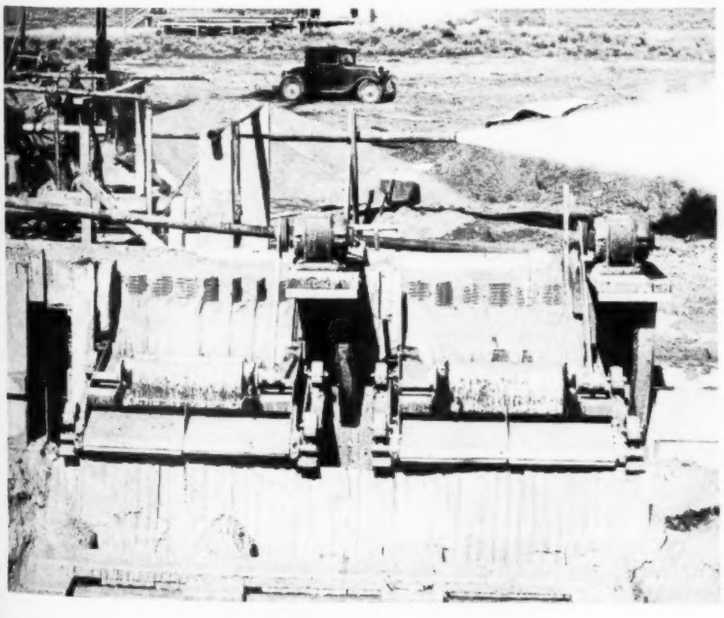
Drilling of the Gulf Production Company's well, McElroy 103, in Upton County, Texas, to a depth now approaching 13,000 ft. (its depth is 12,786 ft. at this writing) is among the year's highlights in deep-drilling progress, as are also the drilling of the General Petroleum Company's well, Berry No. 1 in the Belridge field, California, to 11,377 ft. and its successful completion at this depth, and the drilling of the Denver Producing and Refining Company's well Adah Noc No. 1, Binger, Oklahoma, which reached a total depth of 11,230 ft. and subsequently was completed as a small producer on gas-lift. On August 27, 1859, the Drake well was completed at a depth of 69½ feet. Contrast the drilling of this well with the three deep completions during the past year just mentioned and the phenomenal progress in drilling methods that has been made in this short span of 75 years is at once apparent.

A traveling block of double-deck design has been under test in the Kettleman Hills field, California, during the year. This is something new and full details regarding its performance in the field are not yet available.

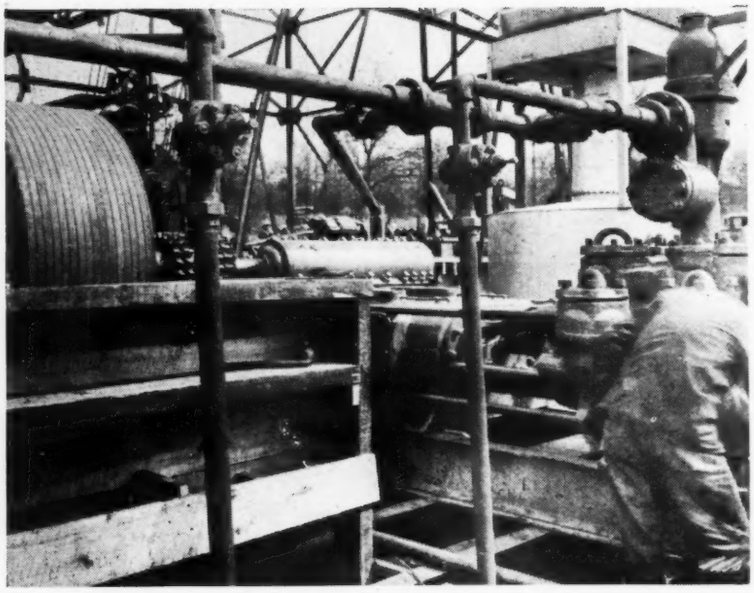
Means for controlling more closely the rate of feed of the bit are still being eagerly sought. Among the latest devices in successful use for this purpose is the Brantly rotary feed control.[1]

A new compact rotary drilling unit with a separate prime mover is another development having for its express purpose the lowering of drilling costs. It has all the flexibility and advantages of steam power. A vertical high-speed steam engine is directly-connected through a reduction gear drive and clutch to the rotary table. This entire unit is compactly mounted upon a structural steel base. Provision has been made so the engine can, if necessary, be used to handle the drill pipe in an emergency.

A new application of electric power in deep-drilling operations is the use of a squirrel cage motor for driving the d-c. generators of a drilling



Dual installation of McNeely vibrating screens to handle large volume of mud and cuttings.



Arrangement of mud lines on Denver Producing & Ref. Co.'s well Sah Cam No. 1, Binger, Okla.

rig.[2] Electric current for the squirrel cage motor is obtained from a 13,200-volt power line. This interesting adaptation of electric power to deep drilling may be the forerunner of many similar installations in localities where the conditions are favorable.

More attention is now paid to the generation of steam for drilling purposes and economies in boiler-plant operation are not being overlooked. An improvement in boiler construction is the riveteless firebox. Thin heat-transfer sheets and short tubes permit a greater rate of evaporation per unit of fuel consumption and hence better steaming efficiency and higher boiler hp. per sq. ft. of heating surface than was possible with the old type of construction.

Superheaters for use at field boiler plants are being more widely adopted in drilling operations. One such modern installation consists of two 125-hp. boilers of 350 lb. working pressure, equipped with one Foster-Wheeler, separately-fired, portable type of superheater capable of handling 15,000 lb. of steam per hour and heating it to 100 deg. fahr. superheat.

A serious drilling difficulty encountered in certain parts of the Fitts pool, Oklahoma, is the loss of circulation while drilling and also the loss of cement slurry while cementing casing. Fibrous sealing materials were experimented with, first in the laboratory and then in the field.[3] These experiments consisted of testing various mixtures of various fibrous materials with: (1) the various drilling fluids; (2) cement slurry; and (3) oil. Other miscellaneous mixtures were also experimented with. Successful tests, based on this preliminary laboratory work, were made in the Fitts pool. One well, drilled to a depth of 600 ft., had been losing a pit of mud every two hours. After adding one ton of the fibrous sealing material to the mud (9 lb./gal.) in the circulating pit and circulating the mixture in the hole a complete seal was obtained. During the whole sealing operation there was a loss of only six inches in the mud pit.

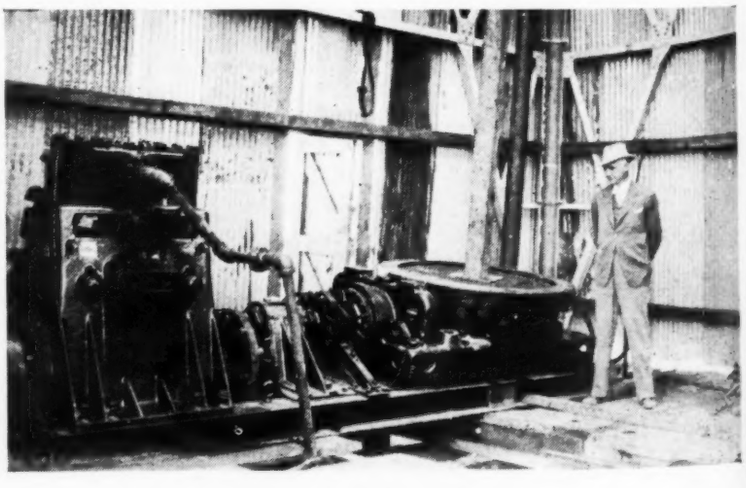
Several strings of casing have been successfully cemented by employing the use of fibrous sealing material in the cement slurry. Two per cent (by weight) of the fibrous sealing material was the proportion used. Further investigations are being carried on with these fibrous materials.

Another effective means of recent development for preventing lost circulation through cavities and fissures, and for drilling through caving and heaving formations, is the use of Gel-cement.[4]

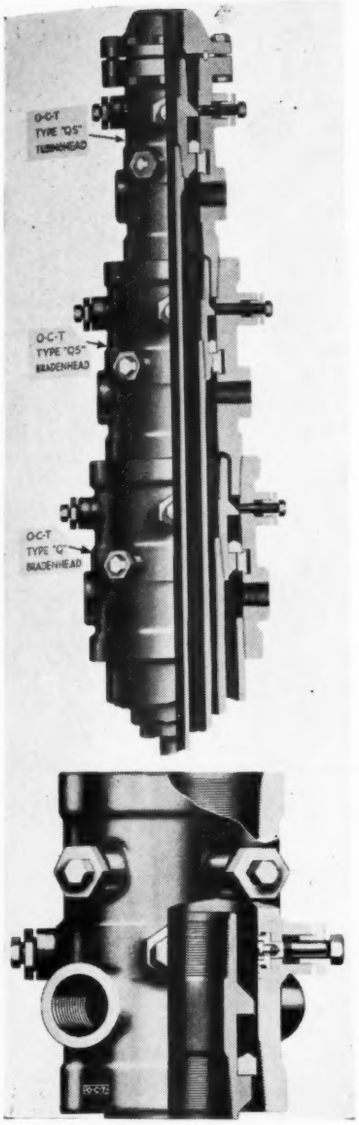
Pressure-operated blow-out preventer and valves. Hook-up used on drilling wells in Gulf Coast.

Mud and mud control are still problems in drilling. Technique in testing and conditioning mud has not advanced to the point that set standards can be laid down. Neither are methods and equipment for testing drilling mud standardized, although it is felt by many engineers, particularly on the Gulf Coast, that they should be. In this district mud control is one of the most important phases of drilling.

Desanding equipment for drilling muds, such as vibrating screens, centrifugal separators, and mud-conditioning ma-



Rotary table direct-driven by separate vertical steam engine placed on derrick floor.



Head designed for 3000-lb. working pressure. Cross-sectional view shows method of suspending casing. Note absence of bolts and flanges.

the most recent applications is the perforation of gas-bearing formations that were shut-off behind the casing. Several wells, perforated under 700 lb. pressure, were brought in as gas wells, the largest of which had an open-flow of 20 million cu. ft. a day.

One phase of drilling operations upon which much thought has been expended is the protection of drilling wells against blow-outs. Recent improvements in the design of casinghead equipment, which includes bradenheads, master gate valves, and blow-out preventers, reflect the demands made on this type of equipment in modern deep-drilling operations. Where heaving shale is encountered in high-pressure areas, it is imperative that wells be adequately protected against blow-out from the time the surface casing is landed until the well is completed. A standard casinghead hook-up in such instances will usually consist of a high-pressure bradenhead on the casing; this is surmounted by a high-pressure master gate valve, and above it a ram type blow-out preventer. Directly upon the blow-out preventer sometimes another blow-out preventer of the slip type and preferably operated by fluid pressure, is employed.

In almost all cases these fittings are designed for 3000-lb. working pressure and are adequately shop-tested to withstand this pressure without leaking.

On p. 20 (center) is shown a casinghead hook-up of recent design for use on a deep drilling well where high-pressures are likely to be encountered. The blow-out preventer, which is of the ram type, the master valve, and also the 4-in. valve on the side opening of the blow-out preventer, are equipped with pressure cylinders so that they can be opened or closed by fluid pressure, and by remote control if desired. Each valve can also be manually operated.

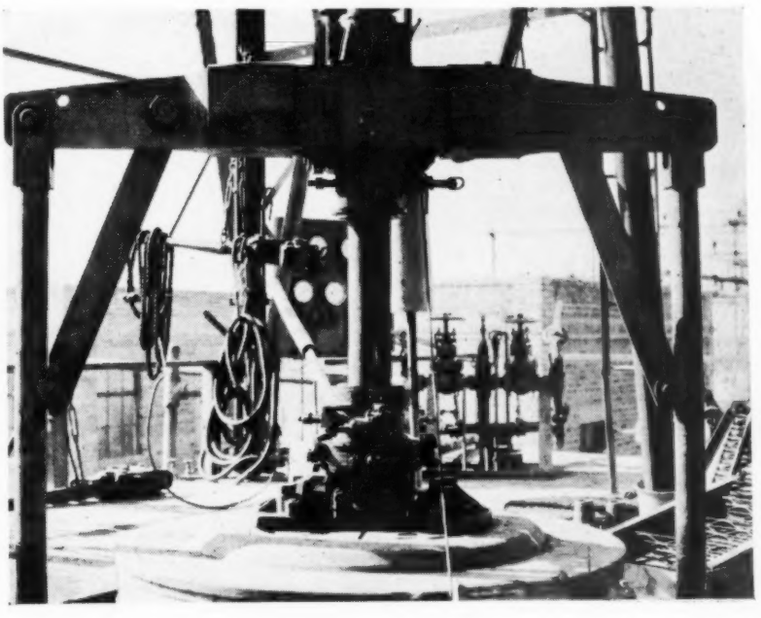
Of the very latest design is the head shown on the left, designed to withstand a working pressure of 3000 lb. and to permit hooking up a well with the greatest ease, speed, and safety. The absence of flanges and bolts is an interesting feature of this head. The half in cross-section shows the method of suspending the casing strings. Except for the large bradenhead on bottom, which is cast chrome-nickel steel, the head is of forged chrome-nickel steel throughout. This type of head is used on several wells in the Fitts pool, Oklahoma.

chines are coming into wide use in deep drilling operations. This is especially the case in the Gulf Coast, where heaving shales are encountered.

New applications of controlled directional drilling have been developed. A well may be deflected by controlled directional drilling methods, a distance equal to one-half its vertical depth. A well in the Gulf Coast has been deflected at a greater angle even than this. New applications of controlled directional drilling are outlined in a recent paper.[5]

Electrical exploration of drill holes, commonly referred to as electrical coring, has been widely used during the past year. An excellent outline of the principles applied in electrical surveys of drill holes and of the principal applications of this method of bore-hole survey are given in a recent paper.[6]

Gun-perforating of casing and liners has been introduced into the fields of the Gulf Coast and the Mid-Continent during the past year. Among



Snubbing device used in pressure-drilling. It is raised and lowered by hydraulic rams, but can be operated with wire lines if necessary.

[1] "New Rotary Feed Control," *The Petroleum Engineer*, p. 27, February, 1935.

[2] "Direct-Current Rig Operated from High Line Used to Drill Binger Well," by W. C. Lane, *The Petroleum Engineer*, p. 34, May, 1935.

[3] "Preventing Loss of Circulation and Cement in the Fitts Pool, Oklahoma," by C. P. Parsons and H. L. McQuiston. Paper presented at the Spring Meeting of the Mid-Continent District, A.P.I. Division of Production, Amarillo, Texas, April 10-11, 1935.

[4] "Gel-Cement—Its Use and Application in Drilling Wells," by W. A. Sawdon, *The Petroleum Engineer*, p. 29, April, 1935.

[5] "Value of Oil Well Surveying and Applications of Controlled Directional Drilling," by James D. Hughes. Paper presented at Spring Meeting of the Mid-Continent District, A.P.I. Division of Production, Amarillo, Texas, April 10-11, 1935.

[6] "Electrical Exploration of Drill Holes," by Alexander Deussen and E. G. Leonardon. Paper presented at Fifth Mid-Year Meeting, American Petroleum Institute, Tulsa, Okla., May 16, 1935.

Gun-perforating operations in well on hillside are being controlled from truck seen in extreme right of picture

By
K. C. SCLATER

Review of Oilfield

ON the whole, the past year has been a period of steady improvement so far as oilfield production practice is concerned. On many old properties that had been allowed to run down, it was a period of rehabilitation, due largely to crude prices having held steady—thanks to a general compliance with the code of fair practice under which the industry was operating. Operators were afforded the opportunity to reap a little profit from which they could make expenditures for much-needed repairs, and they were thus enabled to reduce their lifting costs and conduct their producing operations on a sounder basis.

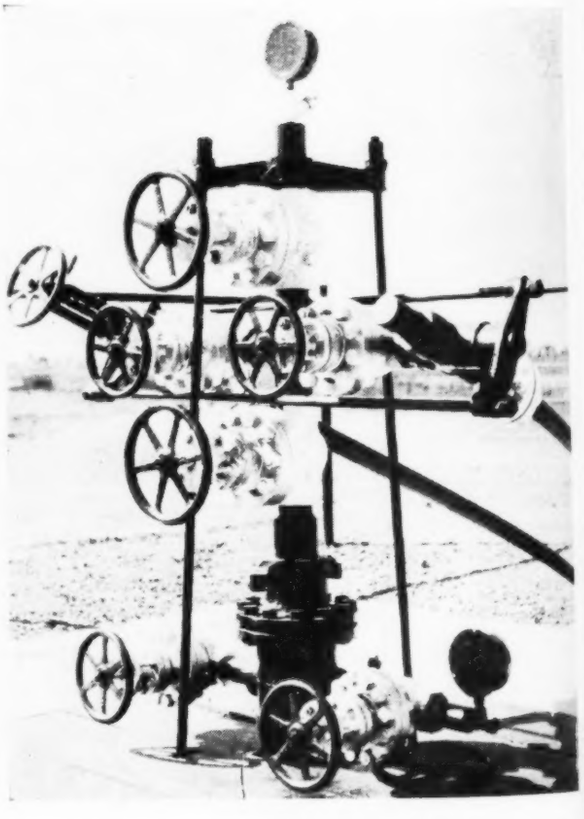
Where feasible, operators are eliminating high inventories by having at the well no standby equipment of the type ordinarily used in pulling and cleaning-out operations. They are finding it more economical instead to use portable equipment for servicing wells.

Probably one of the main factors contributing to this trend is the improved type of portable pulling and cleaning-out equipment now available. Only recently a tractor has been brought out that can be supplied capable of a road speed of either 30 or 15 mi. per hour. This double drum winch tractor is a large capacity machine with eight line speeds ranging from 49 to 1133 ft. per min. and with a line pull of 29,115 pounds. It will handle with ease wells up to 5000 ft. in depth with 2½-in. tubing. The drive for the winch drum is taken directly off the back tractor transmission shaft, eliminating the necessity of power take-offs or accessory transmissions.

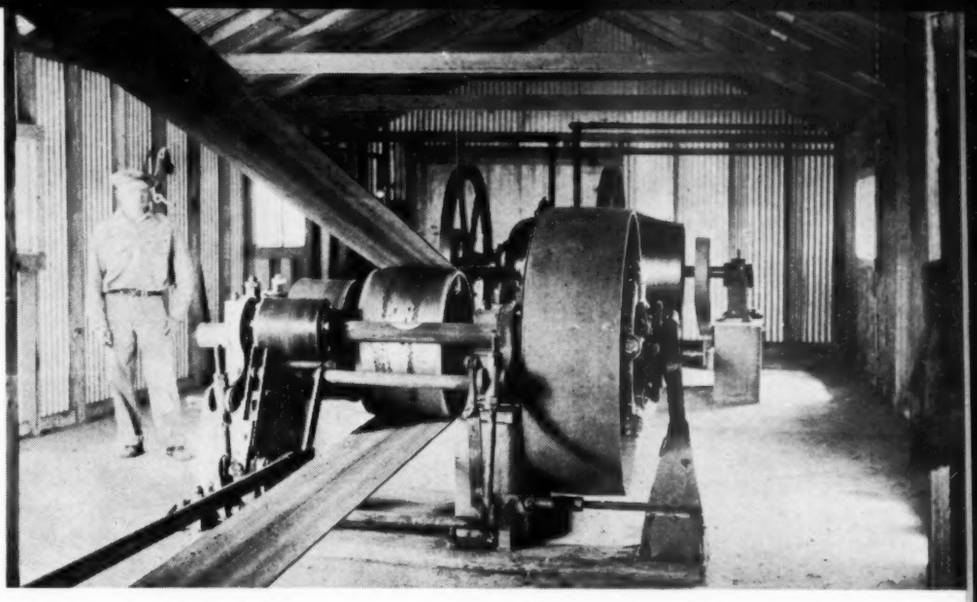
Multiple pumping practice is still popular. Central powers and backside cranks[1, 2] are both in favor. All types of pumping equipment of the individual unit type have been improved in design.

Wrought-iron sucker rods for use in hydrogen sulphide areas to combat corrosion are proving their worth. They are found to be quite successful in combating this trouble where the pumping loads are not too great. The ability of wrought-iron sucker rods to stand up under reasonably heavy loads is surprisingly good. This fact, together with the resistance they offer to sulphide corrosion, is the reason for their increasing popularity.

After several years' study of sucker rods and the kinds of service under which they operate, the opinion is expressed that not more than four different types of sucker rods are needed to satisfy all demands of current operating conditions.[3] The four materials from which the sucker rods would be made must still be determined by operating



High-pressure (5000-lb. test) Christmas tree on a well in the Tomball field, Texas Gulf Coast



Friction reverse clutch used with standard rig and gas engine

experience and tests. It is stated that: "The uncertainty at present is almost entirely concerned with materials for heavy pumping service in sulphide fields and it is doubtful whether the material of greatest ultimate economy has even yet advanced to the stage of field tests."

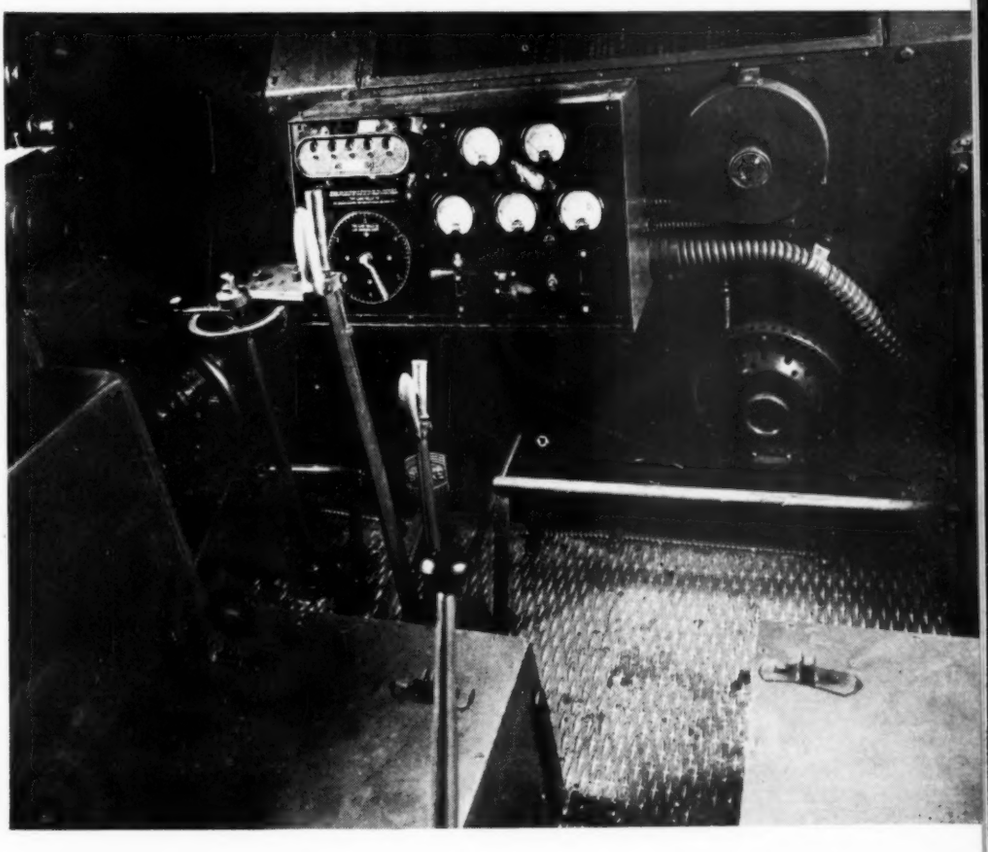
Progress is being made on many vital problems connected with the technical phases of changing reservoir conditions with withdrawal of production. The technique of obtaining and examining subsurface samples is the subject of a paper[4] in which the author states that though fundamental data with respect to reservoirs and reservoir energy may be lacking, the problem can be approached by examining samples of oil and gas that have been procured from the bottom of the hole and brought to the surface for analysis as near their original condition as possible. The technique involved in examining and the instruments used in obtaining samples are outlined and are evidence of a rapidly-developing technique that is bound to make great strides within the next few years.

Much study is being given by engineers to the proper utilization of reservoir energy in the production of oil. More interest is manifest in accurate methods of procuring and the critical analysis of bottom-hole pressure trends in reservoirs with respect to the part they play in production control. The value of shut-in pressures in controlling production has been found to be quite different for the various types of pools.[5] The proper method of control is dependent on the type of pool; that is, whether the source of energy is derived from the water drive, gas pressure, or a combination of water drive and gas pressure. In interpreting bottom-hole data the type of pool must be taken into account. Intensive studies of this kind will eventually result in building up a comprehensive set of data that will be invaluable for guidance in conducting practical field operations.

Petroleum engineers are beginning to show a growing impatience with the expedients resorted to when naturally flowing wells are produced without regard to vital engineering principles dictated by prevailing reservoir conditions. The proper application and utilization of natural reservoir energy in the recovery of oil and gas is still far from what it should be. This fact is forcibly brought home to engineers and responsible production officials when naturally flowing deep wells begin to reach the stage where the energy is insufficient to maintain flow. The cost involved in lifting the oil then becomes an excessive expenditure that might very well have been deferred, curtailed, or entirely eliminated. In discussing the economies that might result by proper utilization of energy it is stated:[6] "The determination of methods of production for the purpose of improving the general economics of oil recovery involves many factors that are entirely foreign to the physical science of the problem and these are the obstacles which are often insurmountable and prevent accomplishment of one of the things which is vital to the continued life of the industry, i.e., full utilization of natural energy.

"Although any industry must recognize and follow eco-

Production Practice



Controls on truck for operation of gun perforator. Large dial on instrument board records accurately the depth of perforator

Pumping unit equipped with backcrank for pumping two additional wells, using a vertical swing take-off

nomic laws in order that it may survive, the right to produce oil economically is denied by the legislative bodies of this country in their endeavor to fit a geographical pattern to a geological condition so that the indeterminable and therefore questionable rights of their constituents may be protected in the recovery of a natural resource that has been created under another's domain and has traversed the property of still many others before it has been captured and held by another's water and produced by still another's gas on a structure that is the property of many more. This condition is being pictured because without the solution of the legal difficulties involved the greatest economies in the recovery of oil may not be effected."

It would seem that a prolonged process of education must be gone through before the full possibilities of economic operation are grasped, particularly when concerned with the intelligent application of reservoir energy to the recovery of oil.

Excellent pioneer work in the metering of oil from wells has been done in the Kettleman Hills field, California. Metering, it appears, is a feasible method for gauging a well's production. Coefficients have been determined for correcting for gas in solution. This is a highly important development that may lead to better well operation by virtue of the fact that an accurate gauge can be taken on the well. This system adapts itself also to the accurate gauging of a group of wells.

Another important development is the hydraulically-operated Kobe pump recently put on the market after field tests extending over several years. Details of the pump are described in another article in this issue.

In flooding operations it is important to producers to know how much oil is retained in the sand. The reliable methods of testing core samples of the reservoir sand and the technique involved are examples of the types of scientific progress in the practice of water flooding.[7]

These are some of the important technical developments that may some day have a far-reaching effect in advancing oilfield production practice.

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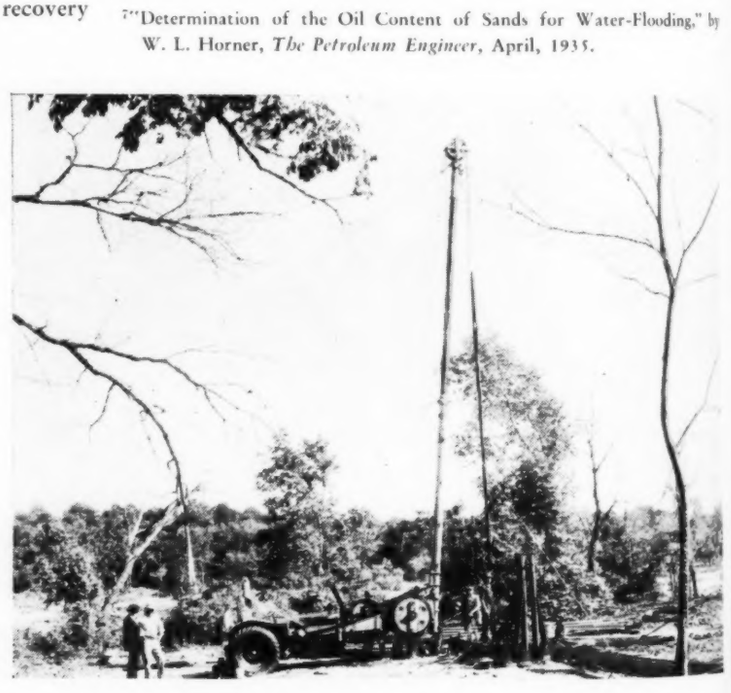


Tractor with double winch. Used in cleaning-out, pulling, or deepening operations

Petroleum Refining in 1934-1935

By
W. L. NELSON
Consultant*

THE increased business activity in the industry as a whole, is being reflected in the refinery branch. Several refineries made a profit in 1934 and most refinery managers feel that 1935 will be a profitable year. Construction companies report an increased number of inquiries concerning engineering construction. The Magnolia Company at Beaumont, Texas, has just contracted for a 32,000-bbl. combination skimming and cracking plant.

A new market condition has arisen during the year concerning the price of bright stock and neutral oil. Since the earliest days of the oil industry, bright stock has been the most valuable lubricating oil stock. In May, 1934, the market price of Pennsylvania bright stock and neutral oil was the same and since that date the per gallon price of viscous neutral oil has been as much as 12 cents higher than the price of bright stock. The same condition has existed in the Mid-Continent area since August, 1934. The difference in price between Pennsylvania 150 stock and 200 neutral oil, and 150 Mid-Continent stock and 400 neutral oil, is shown in Fig. 1.

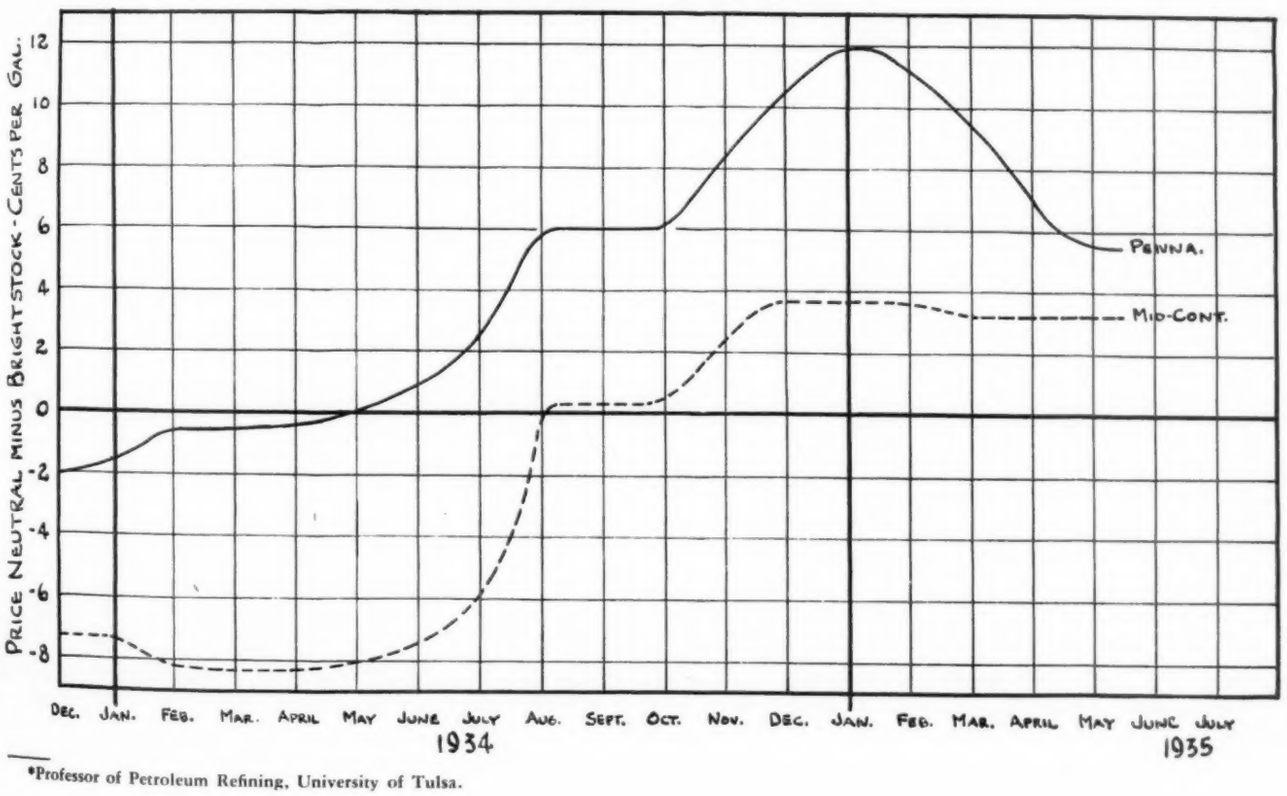
The reason for the more than seasonal demand for neutral oils is the widespread use of low viscosity motor oils. S.A.E. 20 and 30 and the W oils for winter service, are being recommended for modern high-speed motor cars. Although light oils have been recommended for the last three years, the demand for neutral oils did not become acute until 1934 because of the many old cars that still required heavy oils. Motor cars are used for an average of about eight years and hence the peak demand for neutral oil will not be reached until about 1939. At that time it will be necessary to supply about 15,000 bbl. a day more neutral oil than the amount that is present in the crude oil now being processed for lubricants. In compounding S.A.E. 20 and 30 oils, little or no bright stock is used. The condition in the Pennsylvania district is most acute but neutral oils are also becoming scarce in the Mid-Continent area.

The demand for neutrals has been met in several ways. One of these is the processing of more crude oil for wax distillate, and the excess residual stock is processed by cracking. The use of solvent extraction is also helpful because extracted oils have lower viscosities than the stocks from which they are produced. However, such a large loss occurs by solvent extraction that the above-mentioned benefit is of questionable value as far as increasing the total yield of neutral oil is concerned. Still another development is the Vacuum Decomposition Process, by which cylinder stock or bright stock is decomposed into neutral oils (U. S. Patent 1990664). The process is a development of the cracking processes except that decomposition is conducted in a vacuum rather than under pressure. The yield of finished neutral oil of proper color and flash point exceeds 80 per cent. The oils are similar in every way to normal neutral oils except that the viscosity index is higher than the index of the parent stock. The process promises to care for the increasing demand for neutral oils.

Lubricating Oils

The major interest during the year has been the production of superior lubricating oils. Although several commercial solvent extraction plants were in operation prior to 1934, the industry did not fully accept solvent extraction as a necessary treating method until recently. During the year, the engineering principles of solvent extraction have received

Fig. 1. Comparison of the price of bright stock and neutral stock



*Professor of Petroleum Refining, University of Tulsa.

attention. Several plants are now utilizing packed towers for contacting rather than mixers and settlers. The advantages of countercurrent operation, as practiced in a gravity tower system, are being recognized. In general, all countercurrent equilibrium processes involve two factors, namely: the establishment of equilibrium by contacting or mixing, and a separation of the two fluids. In fractionation and absorption the separation of the two phases is relatively easy because one of the materials is a gas, but in solvent extraction, both materials are liquids and the separation or settling of one liquid from the other becomes of great importance. The cost of the settlers with their auxiliary equipment, such as pipe, valves, pumps, level controllers, etc., constitute the major cost of a solvent extraction system. Fig. 2 indicates in a diagrammatic way, the type of contacting and settling system that is being contemplated and installed in several solvent extraction processes. The figure indicates the manner in which solvent extraction can be practiced in a true countercurrent manner and it also serves to show the relation between solvent extraction and other more common countercurrent equilibrium processes. An ideal arrangement would be a tall settler in which the droplets of one fluid settle through the other fluid by gravity but in practical systems the droplets must be collected and re-distributed as shown in Fig. 2. No attempt is made to show mechanical features in the figure. The Podbielniak Centrifuge Contactor and Separator, which will be discussed later, is another means of getting true countercurrent flow in an extraction system.

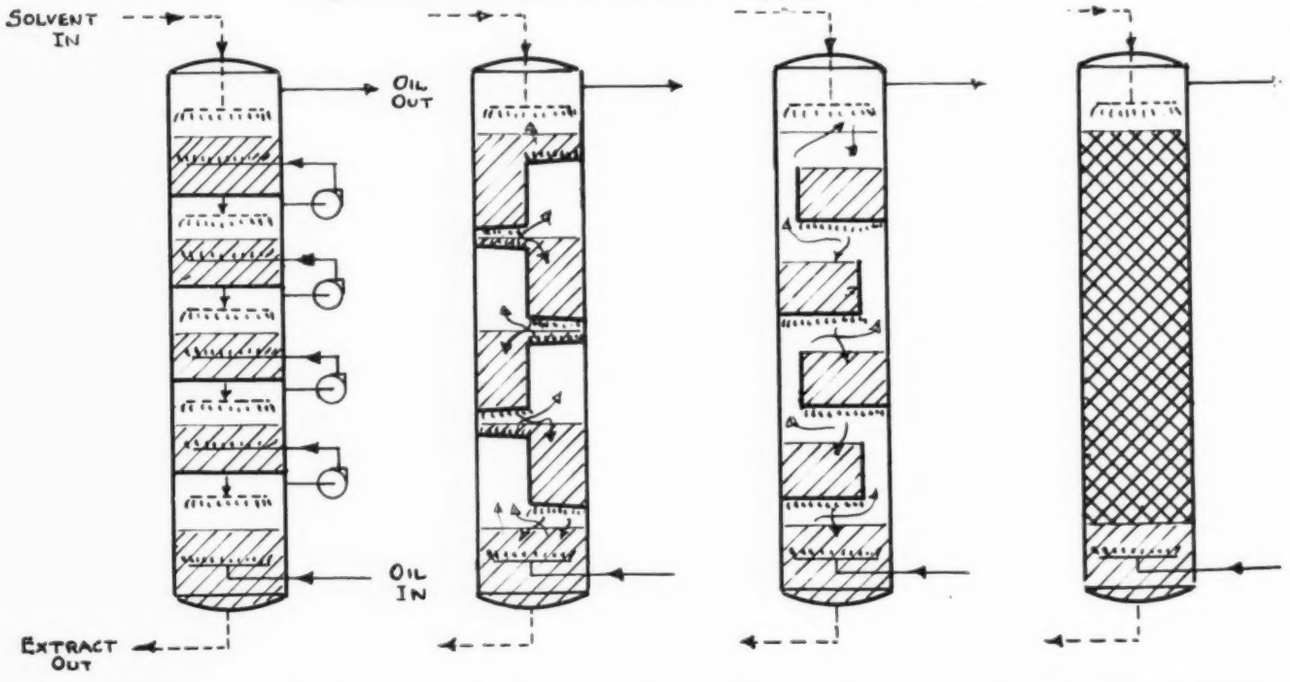
A Petroleum Chemical Industry

For many years chemists and technical men have been heralding the day when crude oil would be used as a base for manufacture of organic chemicals. Developments during the last three years and particularly during 1934, indicate that a petroleum chemical industry is no longer a dream. The petroleum industry is reported to be the largest single consumer of chemicals. Among the chemicals that are used by the industry are sulphuric acid, caustic soda, caustic lye, ammonia, hydrochloric acid for acidizing oil wells, wood alcohol and other antifreeze materials, tetra ethyl lead, adsorbent clays and earths, and the many solvents such as furfural, chlorex, benzene, nitrobenzene, sulphur dioxide, cresylic acid, and phenol. The Union Carbide and Carbon Chemical Corporation has started operating a $10,000,000 plant at Whiting, Indiana, to utilize cracked gas in the manufacture of chemical derivatives, such as organic solvents and alcohols.

The use of petroleum as a base for the manufacture of organic chemicals is not a simple development because the hydrocarbons constituting petroleum are stable ones that resist chemical action. In fact, the hydrocarbons are so stable that they are separated from petroleum only with great difficulty and until the last few years, only a very few of the hydrocarbons had been isolated for study. Indications of the chemical development that is taking place are: (1) the large number of research workers that are isolating pure compounds from petroleum; (2) the active study of petroleum hydrocarbons and the series of hydrocarbons that are hardly mentioned in organic chemistry text books; (3) the commercial development of solvent extraction processes and the development of methods of solvent fractionation; (4) the active study of the pyrolysis and polymerization of the gaseous petroleum hydrocarbons; and (5), the development of commercial polymerization processes for the manufacture of polymer gasoline from cracking-still gas. The work of Dr. Gustav Egloff and his associates of the Universal Oil Products Company in reviewing the technical literature pertaining to the chemical and physical properties of the petroleum hydrocarbons is a real contribution to the industry. The work of T. A. Boyd and his associates in studying the anti-knock properties of the lighter petroleum hydrocarbons is also valuable in the development of petroleum chemistry. Several of the oil companies are conducting extensive studies of the pyrolysis and polymerization of the gaseous petroleum hydrocarbons. Among the hydrocarbons that have been produced by polymerization are the cyclo hydrocarbons having five to nine carbon atoms to the ring.

The author feels almost apologetic for discussing chemistry at such length; however, organic chemistry is rapidly becoming of primary importance and in a few years the petroleum refining industry will be classed as a true chemical industry.

Fig. 2. Illustrations of the countercurrent practice of extraction



Polymerization of Gases

The development of gas polymerization processes to a commercial scale is an outstanding development. During 1934 about 300 billion cu. ft. of cracked gas was produced and if this gas were all treated by polymerization processes, more than one billion gallons of gasoline could be produced each year. This amounts to about seven per cent of the total gasoline production in 1934. Natural gas can also be processed but it must be cracked to produce unsaturated hydrocarbons before polymerization can be practiced. If all our natural gas were cracked and polymerized, the amount of polymer gasoline produced would amount to about a third of the consumption at the present time. The following tabulation indicates the future possibilities of polymer gasoline:

Straight-run gasoline—1934 - - -	156,500,000 Bbl.
Reformed St.-run gasoline (approx.)	50,000,000 Bbl.
Cracked gasoline - - - - - - -	182,400,000 Bbl.
Natural gasoline - - - - - - -	34,600,000 Bbl.
Total Production, 1934 (approx.)	423,500,000 Bbl.
Polymer gasoline, possible production	130,000,000 Bbl.
Possible Production without increasing crude oil runs - - - - -	553,500,000 Bbl.

Polymer gasoline, because of its high octane number, is a valuable blending agent.

Wagner of the Pure Oil Company reports the polymerization of vapor-phase cracked gas without the use of a catalyst. The cracked gas is heated to about 915 deg. fahr. in a tubular heater and after passing through a reaction chamber and cooler, the polymer gasoline is stabilized in a fractionator. The yield of polymer gasoline ranges from 1 to 1.7 gal. per 1000 cu. ft. of cracked gas. The process is conducted at a pressure of 800 to 1000 lb. per sq. inch. He also describes a recirculation system by which the heavier part of the waste gas is recycled through the heater and reaction chamber.

Ipatieff and Egloff of the Universal Oil Products Company report a similar operation except that a catalyst is employed. The catalytic process produces large yields and at the same time the temperature and pressure are relatively low. The cracked gas is heated to about 460 deg. fahr., and passed through reaction chambers packed with so-called "solid phosphoric acid" catalyst. The products are then cooled and the raw gasoline is stabilized. A pressure of about 160 lb. per sq. in. is maintained on the system. About 3½ gal. of polymer gasoline is produced per 1000 cu. ft. of cracked gas. Although the octane number of the polymer gasoline is only 82 by the C.F.R. motor method, the material is much better than an 82-octane fuel when used as a blending agent. In fact, it is more effective than pure iso-octane in raising the octane number of a low octane blending agent.

Centrifuge Contactor and Separator

The centrifuge separator and contactor developed by W. J. Podbielniak, is an invention that promises an extensive usefulness. The separator is suited to the same processing operations as a bubble tower but separation is accomplished by means of centrifugal force rather than the force of gravity. Thus, the vapor velocity through the apparatus can be 40 to 80 ft. per sec., whereas the usual vapor velocity in bubble towers does not exceed four ft. per second. The capacity of the equipment for the space occupied is large and it is possible to provide the equivalent of 100 bubble plates without exceeding practical limits of size.

In one design of the equipment, the vapor or gas travels in a passageway between spiral plates from the outside to the center of the spiral. The spiral plate revolves at a high speed and throws the liquid contact agent or reflux from the center to the outside of the spiral by centrifuged force. Thus, the two fluids pass each other in a countercurrent manner along the entire length of the rotating spiral plate.

The possibilities of such a contacting device if the mechanical difficulties are overcome, are overwhelming. By no stretch of imagination is it possible to conceive of a 200-plate bubble tower and yet the construction of a 500-equivalent plate contactor does not seem impossible. A successful contactor of this nature would permit the separation of hydrocarbon products that are almost impossible today and at a reasonable cost. The equipment can also be used for solvent extraction, water cooling, treating operations, gas scrubbing, air conditioning, and research studies as well as the more common operations of absorption and fractionation.

Separation of the Naphtha Fraction Into Major Chemical Constituents

Successful separation of the naphtha fraction of petroleum into major chemical constituents is now a reality, with the isolation of useful hydrocarbons indicating that the American petroleum industry soon may be producing a whole new series of substances useful to man, the American Petroleum Institute was told by Dr. Frederick D. Rossini, of the National Bureau of Standards, Washington, D. C., at the mid-year meeting in Tulsa.

Dr. Rossini, who is director of the Institute's Research Project No. 6, described as "an adventure in unexplored territory" some 40-man-years of research in determining the chemical constitution of the gasoline fraction of petroleum and declared this naphtha fraction can become an important source of chemical compounds for use in industry and science. He spoke before a group session on refining.

"As the knowledge of the chemical constitution of petroleum increases," he said, "the industry can convert the laboratory methods of separation to a commercial basis, and obtain from the naphtha fraction many new chemicals that have or will find an important economic value. One can visualize the use of some of the hydrocarbon constituents as the starting point in the synthetic production of whole series of new substances useful to man."

Dr. Rossini said this newly-gained knowledge will aid also in improving present and potential utilization of petroleum, with petroleum products having specialized properties better meeting many new and specialized needs. As one instance he cited the possibility of fractionating gasoline so that molecules high in anti-knock value can be separated from those poor in this regard to provide high-octane fuels for aviation use. The knowledge will help also, he added, in profitably controlling refining operations such as cracking and polymerization so that better and greater yields may be available.

He cited a few of the hydrocarbons which soon may be obtained from the naphtha fraction of petroleum, and also from present waste. Among them were series of solvents and base products such as benzene; toluene, a constituent of explosives; a number of xylenes, and the ethyl alcohols.

"In this connection," he said, "it may be pointed out that the aromatic hydrocarbons—benzene, toluene, and the xylenes—present in one year's production of straight-run gasoline alone are estimated to amount to about seven times that produced annually in the by-product coke industry."

Dr. Rossini said 35 hydrocarbons actually have been isolated and identified. Six others have been detected, and 20 others are suspected to be present in significant amounts. He recommended that samples of the newly-available hydrocarbons be supplied to university and other scientific research laboratories so as to permit of the accumulation of important data on their properties and behavior and to expedite the development of new economic uses for them.

Hydraulic Operation Increases Efficiency and Reduces Cost of Pumping Oil

New method has compact surface equipment; permits operating group of small wells from central power unit; and is especially adapted to crooked holes

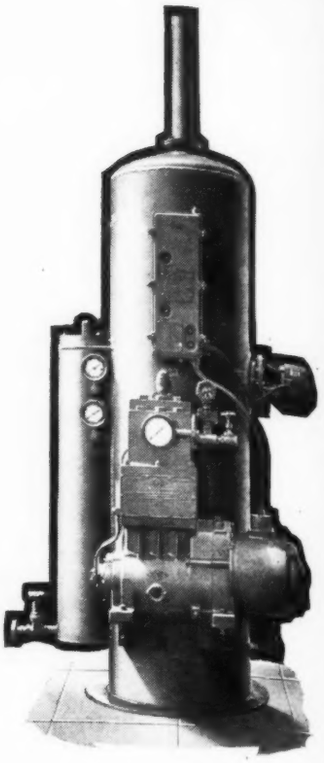


Fig. 1. The Kobe hydraulic power unit

OILFIELD pumping methods have changed but little fundamentally during the past 50 years. Air and gas have been utilized for lifting oil out of the ground in many instances during flush production periods; and numerous attempts have been made to perfect hydraulic equipment for this purpose; but the rigid requirements involved in economically pumping oil anywhere from a few hundred to thousands of feet from wells having widely varying production characteristics have presented problems that stubbornly defied solution by methods sufficiently simple and economical to warrant replacing the old reliable mechanical pumping units.

The Kobe hydraulic pump is one of the developments of the last decade, embracing fundamental changes in the method of lifting oil, which held some promise of practical application to existing field conditions and requirements, and offering desirable advantages from the standpoint of the oil producer. This method was in process of intensive development for a period of five years until the early part of 1931 when performance and results warranted production on a commercial basis. A number of the units were installed in different fields on the Pacific Coast and during the ensuing four years have been operating continuously under a wide range of well and field conditions. The performances of these and other units subsequently installed have been the subject of keen interest among oil men; and complete records of efficiencies, power and operating costs, and general performance characteristics have been maintained by the enginecring departments of the manufacturer and some of the oil companies whose wells are being produced by this method. These four years of operation under the most critical observation have proved beyond question that hydraulic pumping of oil wells not only is feasible and practical, but that it is a reality offering many important advantages not otherwise available.

The Kobe Method

This method differs from all others now or previously used in that it utilizes fluid operation exclusively for lifting purposes, filtering oil from the well and pumping it down through a tubing string as power oil to the production unit submerged in the well, and then returning this oil with the production. The advantages of such a method are immediately apparent. It provides automatic operation, and automatic production control; and a means of economically producing oil from crooked holes and from the deepest wells. More accurate data on well conditions are made easily available, and overall efficiencies are very high. Pumping costs are reduced directly through higher efficiencies, substantial reductions in power costs, and minimum power losses; and indirectly by reduced frictional losses, wear on equipment, and maintenance expense. Surface equipment is not massive, and instead of the usual reciprocating sucker rod string there is a string of stationary tubing. It is adapted to individual wells of practically any depth, as well as for efficiently producing a group of wells of approximately the same fluid level from a central

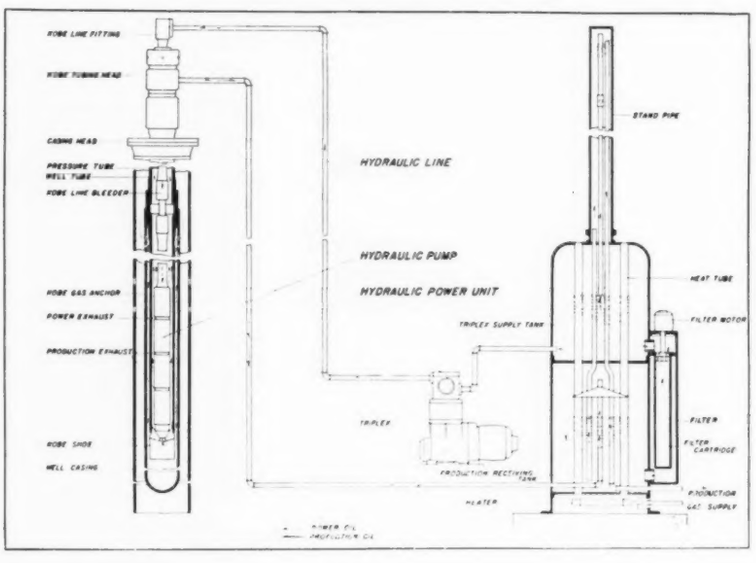


Fig. 2. Flow chart of Kobe hydraulic deep well pump. Production unit on left; hydraulic power unit on right

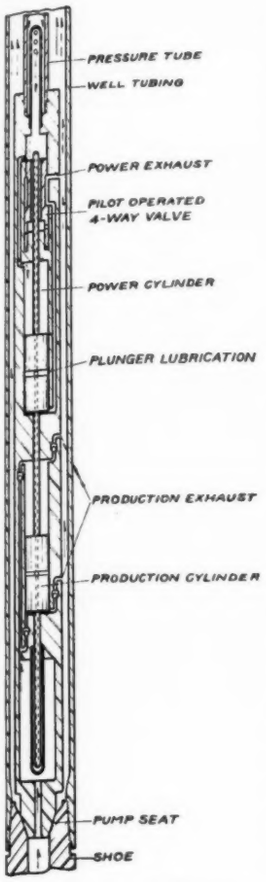


Fig. 3. Sectional diagram of Kobe 2½-in. production unit

power plant. The method also is adapted to pumping oil of any gravity, and embodies a means of preventing wax deposits in the tubing. Of utmost importance is the promise it holds of greatly extending the present limitations of economical pumping to practically any depth, to wells of small size, and to crooked wells.

The Kobe Pump

The pump is supplied complete with all equipment necessary for producing a well except the pressure tubing and well tubing, and consists of two main subdivisions: (a) the surface, or Hydraulic Power Unit; and (b) the sub-surface, or Production Unit.

The surface unit (Fig. 1) consists of a small electric motor, self-tained with a triplex pump and filter system, an operating switch, and gas heater, all combined into a single compact unit that replaces the surface equipment commonly used for pumping wells, such as steam engine, gas engine, or electric motor; speed reducer; pitman arm; counterbalance weights; Samson post; and walking beam. This hydraulic power unit supplies the energy necessary to operate the sub-surface unit, pressure being transmitted from the triplex by pumping the power fluid down through a tubing string to the hydraulic pump submerged in the well (see Fig. 2). Only cleaned production oil is used for power fluid.

The production unit (Fig. 3) consists of an engine and production pump combined in a single unit; the engine comprising a power cylinder with a reciprocating plunger and pilot-operated four-way control valve. The pump plunger and engine plunger are direct-connected, and the complete unit forms a combined motor and pump that is balanced hydraulically, is full double-acting, and operates submerged in the well. It is an insert type and is pulled dry with the pressure tubing without interfering with the surface equipment. Dimensions of the 2½-in. production unit are $2\frac{5}{16}$-in. diameter by 8 ft. 4 in. long, and it weighs 90 pounds.

Operating Characteristics

The motion of the engine plunger is controlled by the pilot-operated four-way valve, which in turn is controlled by the position of the plunger. Approximately two per cent of the power fluid is required for operating the valve. Power fluid enters the valve through the pressure tubing, and in the "down" position pressure is applied to the top of the plunger in the power cylinder and production oil is exhausted from the lower end of the production cylinder. At the end of the stroke the position of the valve is automatically changed to its "up" position and the action and flow are reversed. Exhaust power fluid and production fluid are carried to the surface in the space between the pressure tubing and the production tubing.

The rated capacity of the 2½-in. pump is 200 bbl. per day at a piston speed of 120 ft. per minute. The frictional loss in the tubing usually is less than 100 lb. per sq. inch. Velocities in both the 1¼-in. pressure tubing and the 2½-in. production tubing are less than 1½ ft. per second. Between 50 and 100 lb. per sq. in. frictional pressure is required to operate the production unit, which is designed to operate against a maximum of 4000 lb. per sq. in., corresponding to a static head of 10,000 feet.

Operation of the production pump can be closely checked by readings of the operating pressure, strokes per minute, and the production gauge. Any important change in operation shows immediately in one or another of these readings, and can be accurately interpreted.

Operating Records

Accurate records of these pumps operating in different fields under widely varying well and field conditions show overall efficiencies ranging from 53.8 per cent to 68.5 per cent with a conservative average of approximately 60 per cent. Costs in kw-hr. per bbl. range from .45 to 1.71, with only one well recording higher than 1.57; the average lifting cost being 0.194 kw-hr. per bbl. per 1000 feet. The wells are in different fields, producing from 39 to 160 bbl. per day of oil ranging in gravity from 21.8 to 33.6 deg. A.P.I. and 0.2 per cent to 52.2 per cent cut. The installations comprise individual wells and groups of wells operated from a central power unit. Pump settings range from 2007 ft. to 8700 feet.

In each instance the equipment has been operating continuously for long periods, under automatic production control, so that all figures recorded represent average rather than peak performance. The following table gives detailed production characteristics of four of these wells

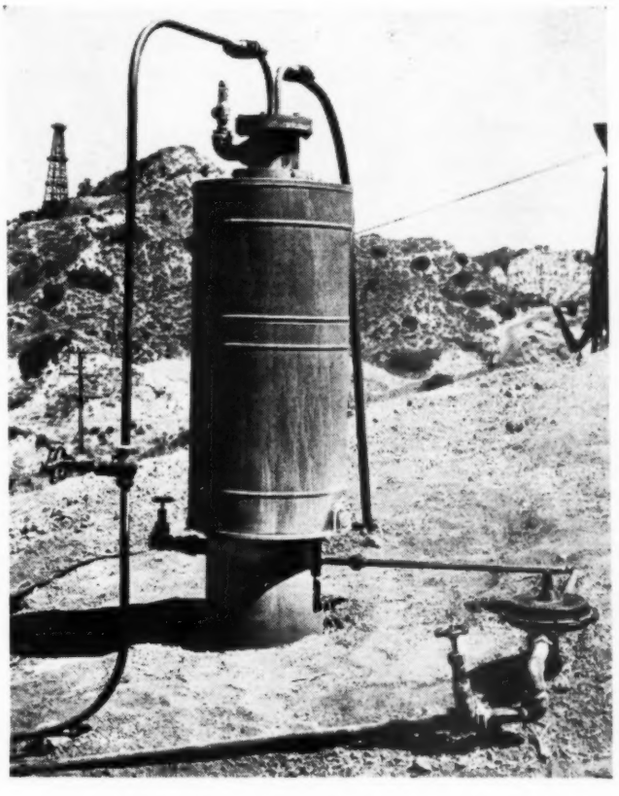


Fig. 4. Heater installed in high-pressure system for preventing wax deposits in tubing

Records of Various Wells Equipped With Kobe Hydraulic Pump

Wells Were Equipped with 2½-in. Kobe Pumps Using 2½-in. External Upset Tubing for Outer String and 1¼-in. External Upset Tubing for Inner String.

	Well No. 1	Well No. 2	Well No. 3	Well No. 4
Pump Setting (Ft.)	2007	5900	6450	7200
Motor:				
Horsepower	1½	7½	5	7½
Speed (r.p.m.)	972.5	1464.5	1468.4	1447.0
Frequency (cycles)	50	50	50	50
Volts	443	434	477	482
Amperes	2.32	6.40	7.40	10.0
Load Factor	93.0%	55.2%	93.5%	98.0%
Electrical Input (kw.)	1.04	3.76	4.16	6.53
Electrical Input (hp.)	1.39	5.06	5.57	8.76
Motor Efficiency	78.5%	82.5%	84.0%	84.0%
Power Unit:				
Speed (r.p.m.)	133.0	131.0	130.5	128.7
Pressure (lb./sq. in.)	1000	2020	2550	2825
Temperature (deg. fahr.)	86	167	109	110
Delivery (gal./min.)	1.771	3.405	2.89	4.22
Delivery (bbl./day)	60.8	116.8	99.3	144.6
Displacement (gal./min.)	1.800	3.52	3.06	4.46
Volumetric Efficiency	98.5%	96.7%	94.4%	94.6%
Hydraulic Output (hp.)	1.028	4.00	4.31	6.95
Power Unit Efficiency	74.0%	79.0%	77.3%	79.5%
Pump:				
Gross Fluid (gal./min.)	1.745	2.637	2.395	3.40
Gross Fluid (bbl./day)	59.9	90.42	82.2	116.8
Wet Specific Gravity (A.P.I.)	.925	.910	.884	.918
Cut (per cent)	8%	.....	28%	52%
Temperature	94	105	94	107
Speed (stk./min.)	18.3	30.5	26.4	38.4
Volumetric Efficiency	99.8%	95.1%	94.8%	95.5%
Production:				
Hydraulic Output (hp.)	.803	3.448	3.45	5.68
Overall Efficiency	57.5%	68.5%	62.0%	65.1%
Former Power Unit:	Elec. Motor	Elec. Motor	Gaso. Engine	St'm Eng.
Hp. Used	7.5	17.0	15.0	.....
Overall Efficiency	10.8%	20.3%	23.0%	.....

and clearly demonstrates the adaptability of the Kobe method to widely varying conditions. Comparisons with former production methods are particularly interesting, as they show large reductions in hp. used, and increased efficiencies of 300 to 500 per cent.

Wax Problem Solved

It seems to be well assured that practically any paraffin problem can be overcome and the necessity of pulling wells for this cause eliminated, judging by the successful experience in handling very stubborn wax conditions. Ordinary troubles of this type are taken care of by heating the power oil, which is pumped down to the production unit, to a temperature sufficient to maintain the wax in solution (see Fig. 4). This additional heat also contributes to the efficient pumping of heavy oils. When exceedingly stubborn wax problems are encountered, as in one instance, they are taken care of by regulation of both the heat transmitted through the power oil, and of the operating characteristics of the pump itself.

The particular instance referred to was that of a group of wells operated with a central power unit. Excessive gas and wax conditions had necessitated pulling and steaming the tubing on an average of approximately once every three weeks, and caused other difficulties in operation. A Kobe plant was installed and included a means of heating the oil to 150-175 deg. fahr. at the well head; this successfully maintained the wax in solution in both the power and production tubing and eliminated the necessity of further pulling and cleaning jobs. Approximately three months after the plant was installed, the tubing was pulled for inspection purposes. All the tubing was found to be clean except for a small amount of paraffin inside the first 20 stands. The quantity was not sufficient to affect operation of the pump, however, and further regulation of the pump and heating unit completely eliminated this trouble. Since then there have been no signs of paraffining.

Should a wax condition develop in a well being produced with the Kobe method, it is possible in practically all instances to dewax the tubing without pulling the string, even when a considerable deposit of wax has been allowed to accumulate. It also is possible to determine what heating and operating procedure is necessary successfully to handle existing wax conditions in a well, prior to installation of the pump, by making tests of samples of the production in the Kobe laboratory, thereby eliminating difficulties from this source after the complete pumping unit is installed.

Producing From Crooked Holes

This method of pumping has proved exceptionally successful for pumping crooked wells beyond the range of other methods. A specific example of this character is provided by a well that was too crooked to be operated by the conventional rod pump. Subsequently the well was flowed by the gas-lift method, the production ranging downward from 116 bbl./day to approximately 30 bbl./day over a period of 30 days, when it quit flowing.

Fig. 5. Control valve and well head of one of a group of wells operated by a central power unit

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Just in case you haven't thought about it, the oil industry is the most exacting customer in the world for pipe wrenches. The needs of the oil fields for strength, durability and safety call for something special.

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Fig. 6. Kobe pump installation with hydraulic power unit placed on derrick floor, showing hook-up with subsurface unit and control equipment at the surface

Some time later a single-unit Kobe pump was installed in this well, the pump being set at 5000 feet. The plant has been operating continuously under the supervision of the regular pumper crew, pumping 110 bbl./day of 28.9 deg. A.P.I. oil cutting 12 per cent, with no indication of impaired operation due to crooked hole.

Installations in crooked holes of widely varying degrees of irregularity show the same high efficiencies, reduced pumping costs, and general advantages as those in straight holes of average production characteristics; indicating that the only limitations in this respect of pumping by this method are holes of such extreme irregularity as to make installation of the well tubing impossible.

Central Plant Operation

The method has proved equally as successful for operating a group of wells of approximately the same fluid levels as for individual installations; showing the same advantages and economies in both types of service. In one instance, accurate records were maintained of a central plant operating both four wells and five wells at different periods. When pumping four wells the triplex pump in the hydraulic power unit was equipped with 1¼-in. pistons; when pumping five wells it was equipped with 1⅜-in. pistons. The production from four pumps was 160 bbl./day; and with five pumps 200 bbl./day. Total power consumption of 114 kw-hr./day and 159.7 kw-hr./day, respectively, included operation of the filter unit. Average volumetric efficiencies were 92 per cent in both instances. The overall field efficiency of the power unit and pumps when producing four wells was 52.5 per cent. When producing five wells it jumped to 61 per cent. The total cost of operating this plant was approximately one-third of that previously used. The data covering this centrally-operated installation are as follows:

	Producing 4 Wells	Producing 5 Wells
MOTOR:		
Capacity	7.5 hp.	7.5 hp.
Speed	1475 r.p.m.	1470 r.p.m.
Frequency	50 cycle	50 cycle
Electrical Input	4.5 kw./6.05 hp.	6.53 kw./8.75 hp.
Motor Efficiency	84%	85%
POWER UNIT:		
Speed	131 r.p.m.	131 r.p.m.
Pressure (lb./sq. in.)	1300 lb.	1500 lb.
Delivery	209 bbl./day	264 bbl./day
Displacement	6.23 gal./min.	7.83 gal./min.
Volumetric Efficiency	98%	98.5%
Hydraulic Output	4.63 hp.	6.74 hp.
Power Unit Efficiency	76%	77%
PUMPS:		
Av. Volumetric Efficiency	92%	92%
Production	160 bbl./day	200 bbl./day
Overall Field Efficiency	52.2%	61%
Total Power Consumption	114 kw-hr./day	159.7 kw-hr./day

In this particular installation, considerable difficulty was caused at first by the extreme wax condition, and the data above apply to a period after that condition had been overcome and the installation was operating properly; representing an average over a period of four months.

Wide Application

The adaptability of the Kobe pump is clearly indicated by the operating data here given, the results having been obtained under a variety of conditions. As already pointed out, with this method of pumping it is possible to measure periodically the fluid level of the well, thereby permitting better control of the well's production and more precise measurement of the well's capacity. Total investment compares very favorably with other pumping methods, while the advantages offered are readily apparent in the efficiencies and economies recorded.

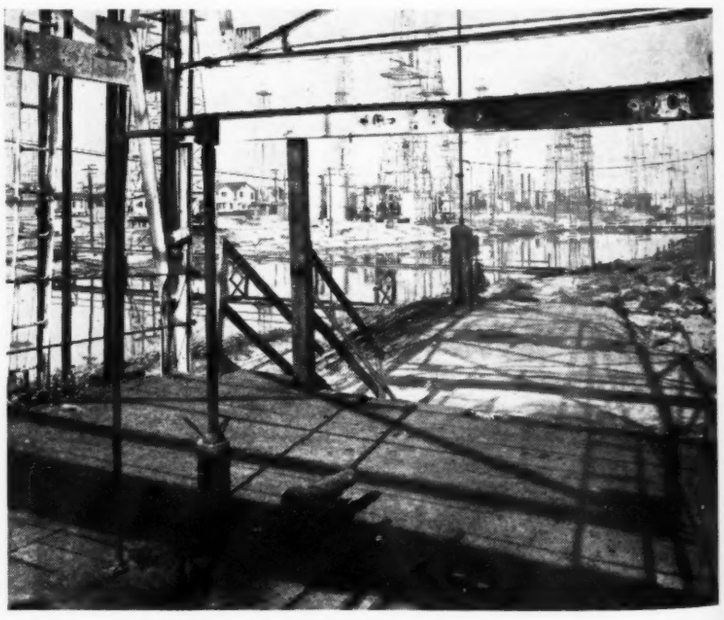
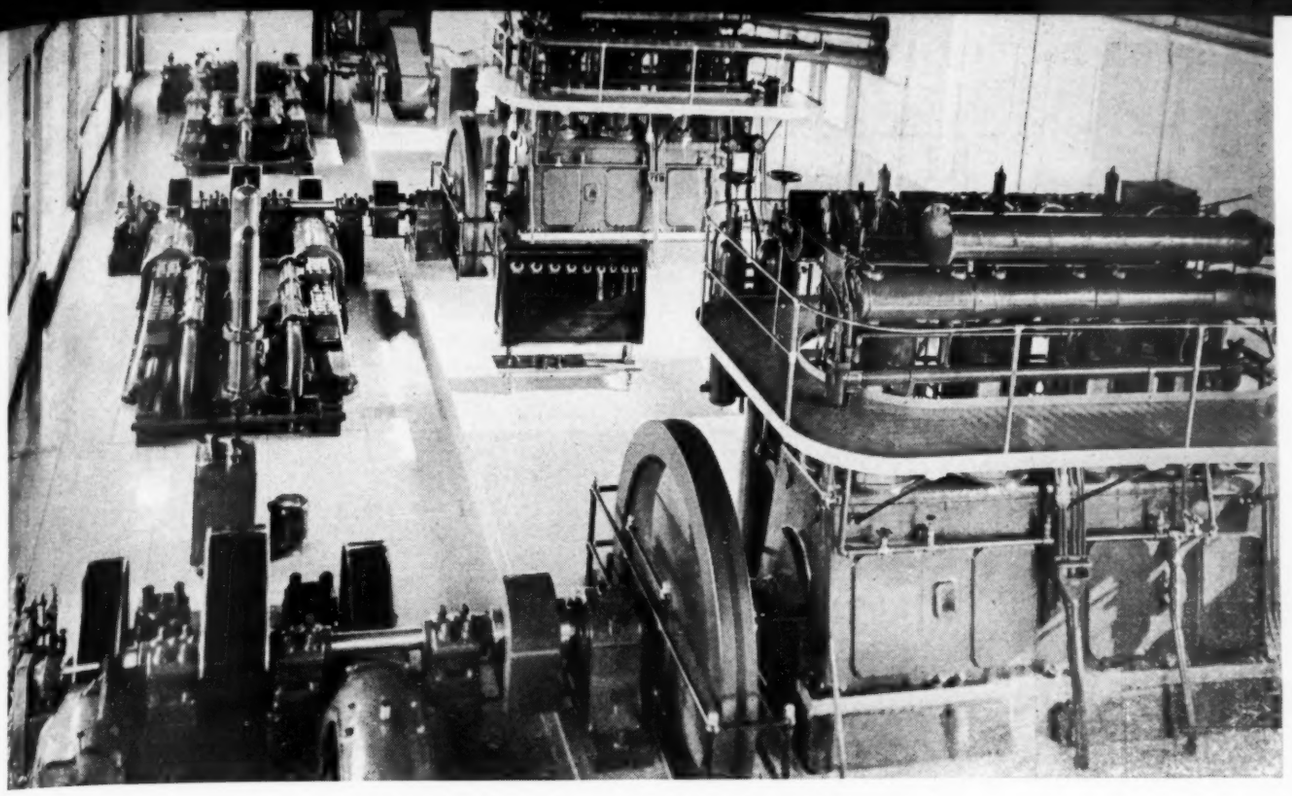


Fig. 7. Kobe pump installation with hydraulic power unit placed some distance from the well



Interior view of a modern pipe line station

Progress and Trends in Pipe Line Practice

By FRANK H. LOVE

THE past year has seen increased activity in the construction of pipe lines—gas, gasoline, and oil carriers. There has been a marked trend toward the reconditioning of old lines and the laying of new ones with salvaged pipe. Reconditioning work has been featured by a steady advancement in technique as well as in the equipment used. Experiments have continued to determine the coatings best suited for pipe protection, as well as for the determination of other methods for combating corrosion. Several important advancements have been made in welding technique and equipment. In the matter of pipe line operation officials have directed their attention perhaps more than ever before toward greater efficiency and the reduction of maintenance costs.

Reconditioning Pipe[1]

While the reconditioning of pipe lines is not a new practice, within the last year it has assumed a position of added importance. Procedure has become more standardized, and various new equipment has been devised, making possible the accomplishment of the work in a manner even more rapid and economical.

Several new lines were laid during the past year, either wholly or partly, of salvaged pipe. Considerable work was, and is being, done on pipe lines that are still in use, but, due to years of service, require reconditioning. These two phases of reconditioning require somewhat different methods of procedure.

So far has reconditioning technique advanced that it is possible to rework oil lines without a shutdown in pumping operations except for "hot spots" where line pipe is so badly corroded that replacement is necessitated. The usual practice in such cases is to wait until several sections of pipe are ready for replacement, shut down the necessary stations, and accomplish the work all at one time, reducing to a minimum the delay in the movement of the oil.

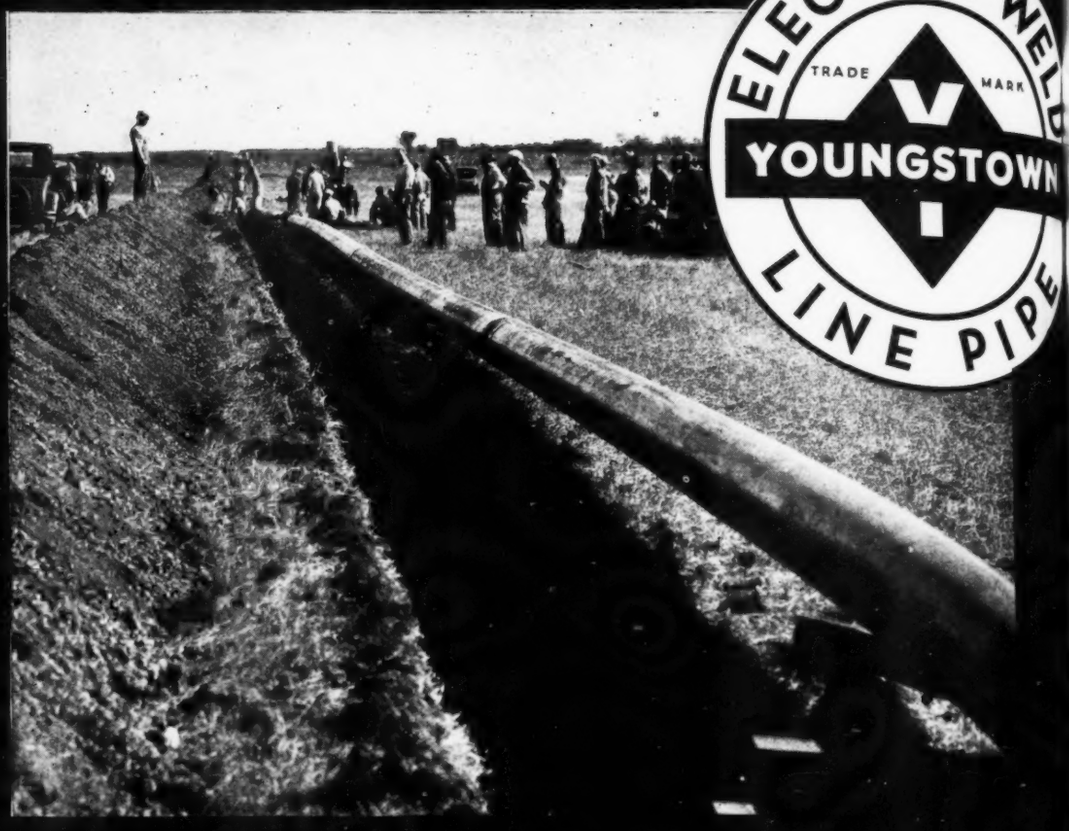
The initial step in a reconditioning program, of course, is to locate and "flag" the line. The general practice is to employ an underground pipe locator for this purpose. The locator utilizes the principle of the radio, and consists of a high frequency transmitter and a specially designed portable radio receiver operating with a selective directional loop antenna, the latter being carried in the hand of the operator. The pipe line and connections are excited by the transmitter, which transmits high frequency pulsations between two grounded points. The signal is heard by the operator when he is directly over the line, being picked up by the loop and in turn detected and amplified by the radio receiver.

After it is determined what portions of the line require reconditioning a ditcher is used to strip the pipe. Until recently the soil was removed to the top side of the pipe only, but a stripping machine has now been manufactured that digs down to the pipe and also plows out the trench on either side to a depth of one-half the diameter of the pipe, leaving it fully exposed. Hand-digging operations are eliminated and it is possible for the raising crew to follow immediately behind the stripping machine and easily to hoist the pipe in position for cleaning.

With the stripping crew's work accomplished, the raising "gang" follows and lifts the pipe approximately a foot above

[1]See references at end of article on page 42.

ELECTRIC WELD



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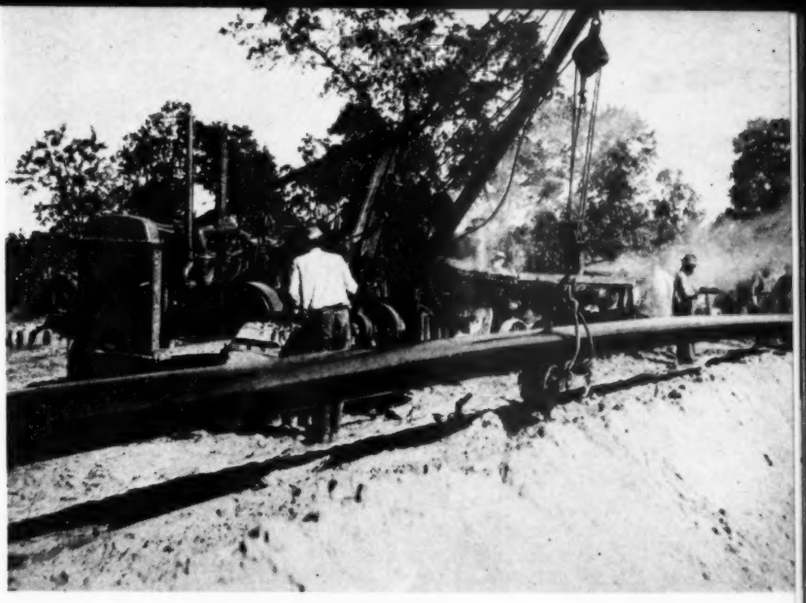

The Lone Star Gas Company's line from the Long Lake gas field to a point on its main line near Waco, completed last fall, was coated and wrapped

ground level, where it is blocked up on skids over the trench. The pipe is raised either by tractors equipped with booms or by a special pipe handling hoist and tripod. On the latter equipment a clevis is provided at the hinge of the legs of the tripod for the convenient attachment of the hoist, which operates on a straight ratchet principle, pump handle style. Loads are raised or lowered by short strokes of the handle. A small lever on the hoist frame controls the movement up or down. While in this position a cleaning machine of the traveling type is passed over the pipe. The machine is equipped with scraper knives, steel cutter wheels, and steel wire brushes. Rotating around the pipe they remove rust, dirt, corrosion, old coating, wrapping, and mill scale. Placed on the pipe line the machine travels under its own power, cleaning two miles or more of pipe per day, and is designed to negotiate sags, overbends, and sidebends. The machine has a stationary base attachment upon which it can be mounted for cleaning single joints of pipe.

Another traveling cleaning machine is a small lightweight power-driven type designed for short reconditioning jobs, or for cleaning new pipe. Thorough cleaning is accomplished by a series of toothed cutter wheels that rotate around the pipe and produce a chipping action. This machine may be fitted with cutters only, cutters and brushes, or brushes only, and is often used for cleaning pipe in the ditch, as it requires but little clearance and cleans close to the valves, collars and other fittings. Power is furnished by a single-cylinder air-cooled engine that revolves the cleaning head around the pipe at 110 rev. per minute. The machine travels along the pipe at speeds varying from two to 10 ft. per minute, depending upon the condition of the pipe and the degree of cleanliness desired.

For work in close quarters, in and around obstructions, or on short sections of pipe, between valves or other fittings, on short "hot spots," etc., a hand-operated machine is used. This machine also is equipped with cutter wheels that produce a chipping action.

Following the cleaning of the pipe an inspector measures the depth of the pits, marking where patches should go and where spot welds should be made. The welders then follow, making the repairs. Such sections of pipe as are beyond repair are marked and when sufficient in number to justify shutting down the pumping units all replacements in the area are made simultaneously.

Gas companies usually vary this reconditioning procedure and employ the "loop" method, since it is virtually impossible for them to shut down their line at any time and leave the consumer without service. A line one to five miles in length is laid parallel to the section to be reconditioned and "cut in" to the main line. The bad pipe is then removed, taken to a central yard, reconditioned, taken back to the job and used as a "loop" where another section is to be reconditioned.

Many lines recently reconditioned were originally laid when special pipe line coatings were unknown. Some companies are now coating their lines as they recondition them, others follow a policy of coating the "hot spots" only. In some instances hot enamel preceded by a primer is applied, after which the whole is wrapped. On one large reconditioning project now under way, that of the Magnolia Pipe Line Company in Texas, a rust preventive compound is being applied to the pipe by hand, following by a wrapping of chemically-treated muslin, and finally by a coating of water-proof paint.

When an unused line is to be taken up and the pipe reconditioned for use in a different locality, it is general practice to establish central plants for the work. The pipe is removed from the ditch in the same manner as before described, but, prior to being hauled to the central plant, is cut into sections. There it is made ready for further use by straightening, cleaning, patching, and spot welding. The first two operations are accomplished by the use of cleaning machines of the stationary type. The machines, equipped with rotating steel cutter wheels, scraper knives, and steel wire brushes, are so devised that pipe can be run through them at varying speeds, as the condition of the pipe may necessitate. Some can be operated at four speeds, ranging from a compound low, requiring six minutes for a 20-ft. joint to pass through, to a high speed requiring but one minute. A low speed is used when the pipe is badly corroded, and frequently it is passed through the machine several times.

Another method of cleaning, although not so widely used as the cleaning machines, is sand-blasting. The pipe to be cleaned is placed on racks. A gasoline compressor connected to storage units, which, in turn, are connected to a drying and mixing container for the sand, provides the power for the blast and the sand is blown through a steel nozzle.

Pipe that has been coated sometimes presents an additional problem. Coatings are not always so easily removed as scale, and at times resist the usual procedure. In such cases the problem has been solved by placing the pipe in gas-fired ovens and subjecting it to an extremely high temperature, usually around 1100 deg. fahrenheit. At that temperature the coating is burned away and the oxidized scale loosened.

After the pipe is cleaned by one of the means described, it is inspected and marked for patching and spot welding; then graded, beveled, and stacked ready for shipment. It is becoming standard practice to grade the pipe according to the depth of pits and when relaying to select the best for use where pumping pressures will be greatest.

Two methods are followed in the application of coatings, one being to apply it at the central reconditioning plant, the other to make the application in the field. When the former plan is adopted the joints alone are left to be coated in the field. In following the latter procedure it is common practice to run a traveling-type cleaning machine over the line after it has been tied in to remove any dirt or dust accumulated since the pipe left the central reconditioning plant. This machine rides the top of the pipe and usually is equipped to apply the primer and clean the pipe all in one operation.

Corrosion

The problem of corrosion is one of increasingly great importance to every major pipe line company. In the matter of coatings the trend has been somewhat toward the treating of

the pipe in "hot spot" areas only, rather than over the entire line. A widespread theory is that where the soil is known to be "sour" too much cannot be done to protect the pipe against its attack, whereas in "sweet" soils no protection in the form of a coating is needed. This practice of concentrating expenditures and effort on the "hot spots" is believed to result in an average longer life for pipe line systems as a whole, at the same time sharply reducing maintenance costs.

Experimental tests are constantly being conducted to determine the type of protective coatings best suited for certain kinds of corrosive soils. From time to time a new coating is brought to the attention of the industry. During the year a rubber coating and a celluloid covering, or shield, were announced, proving of considerable interest, although tests have not yet been completed and the exact significance of the products cannot be accurately determined at this time.

Early in the year two test installations of the rubber coating were made on pipe lines in Texas, one on a gas line, the other on a gasoline carrier.[2] The field tests were a consummation of several preliminary tests made over a period of years. Previously the coating had been tested mechanically for its resistance to soil stresses, and samples of pipe coated with the compound had been buried in corrosive soil for two and a half years. These proving satisfactory, the field tests now in progress are the next step in determining its commercial value.

The test sections of pipe were coated at the factory, the rubber being cemented to the surface of the pipe in an unvulcanized state. The unvulcanized rubber is of a soft texture, but upon being put through a vulcanizing operation, a direct steam-heated process, becomes of a hard but flexible consistency. The coating was applied to the pipe to a thickness of ⅛ in. and to within eight in. of each end of the pipe, to allow for welding. After the joints were welded in the field, vulcanized soft rubber sleeves were cemented over the exposed surface of the pipe and wired into compression, forming a continuous insulated line. In time a freeze results between the soft and hard rubber, rendering them virtually integral. While the sections of pipe used in making the tests were coated at the factory, officials of the manufacturer state that should it be found commercially practicable, applications can be made in the field without difficulty.

Celluloid, used as a shield to protect the bituminous coating applied directly to the pipe from soil stresses, has been found satisfactory in the field tests made to date.[3] The material, known as cellulose nitrate plastic, is inflammable, flashing at 525 deg. fahr., and has a tensile strength of 8000 lb. per sq. inch. At minus 20 deg. fahr. it becomes brittle, and at 220 deg. fahr. softens. Rapid decomposition sets in at 325 deg. fahrenheit. When hard it shrinks 12 per cent by volume, but does not crack or break, merely adhering more closely to the pipe. Ultra-violet rays will cause it to break down and for this reason it should not be exposed to the sunlight for any length of time. Atmospheric exposure has no effect upon it, however, and neither will it deteriorate so long as it is in the ground. The cellulose nitrate plastic comes in thin layers and is shipped in rolls. Strips are cut, the width depending upon the size of the pipe, and the material is spiral-wrapped to the pipe, a quick-setting cement being brushed along the edges as applied.

When raised places are encountered, such as collars, patches, etc., a softening compound composed of alcohol, ethyl acetate, and water is used. Its action is to make the material soft and pliable without causing it to crack or break, thus it can easily be molded to meet any emergency.

Electrolysis is one of the major causes of pipe line corrosion and has resulted in expenditures of large sums for pipe reconditioning and replacement. One of the most effective means of combating this condition has been by cathodic protection, the placing of a positive electrical current in the soil near the pipe line where the potential or resistance is low, from where it passes through the soil to the line and back to the generator. In this manner the potential relation of the pipe and the surrounding soil is controlled and corrosion reduced to a negligible factor.

In the past the application of cathodic protection to pipe lines not accessible to electric power lines has presented a problem. Recently the Texas Pipe Line Company developed a wind-driven generator unit that has solved the difficulty.[4] A direct-current generator, specially wound to protect it against overloading at high speeds and to give a constant current at variable speeds, is equipped with a two-blade propeller that drives it through a speed-increasing gear. The entire assembly, together with collector rings, is mounted on a turntable, and set up over the pipe line on a tower. One line is connected to the pipe, another, that carrying the positive current from the generator, is strung on poles for a distance of 1000 ft., and grounded. The ground bed consists of eight sections of pipe driven into the ground in an upright position across the tops of which another section of pipe has been welded. To this the lead-off line is anchored.

Rotation of the propeller starts when wind velocity reaches nine miles per hour and will continue rotating during lull periods after the velocity has receded to as low as two miles per hour. It is believed that, when completely broken in, the unit will require but five miles per hour wind velocity to start its operation. An automatic brake shuts the unit down when the wind becomes too strong, usually at 25 to 30 miles per hour, although it can be regulated for any desired velocity.

Engineers of the Texas Pipe Line Company have determined that this set-up will give full protection to the pipe for a distance of five miles.

Cleaning pipe with a traveling-type machine

Line Construction

While pipe line construction procedure now follows a somewhat standardized program, new equipment and methods are constantly being developed to add to the effectiveness and economy of such work.

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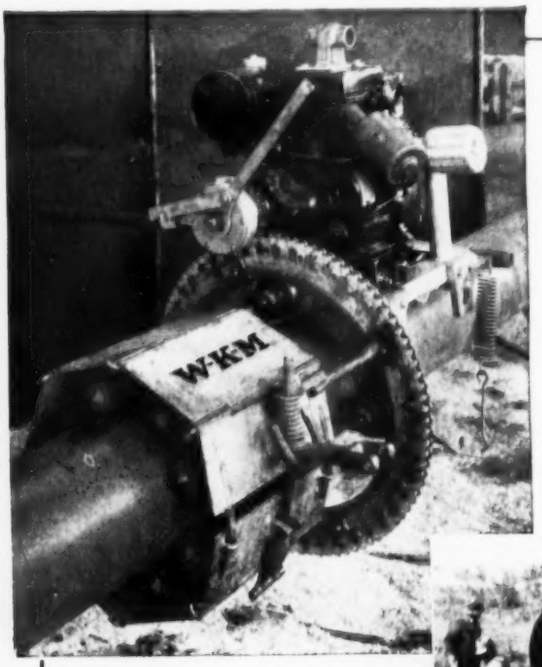
PIPE STRIPPER

To such pipe line companies as are confronted with the necessity of crossing a large body of water such as a lake or bay with their line the equipment and procedure evolved by engineers of the Texas Cities Gas Company, subsidiary of the Lone Star Gas System, in repairing last summer their carrier laid on the bottom of Galveston Bay was of interest. A portion of the pipe was found to be so badly corroded it was in need of replacement, and officials of the company determined to accomplish the work in mid-bay without making up the sections of pipe on shore and floating them into place, thus effecting a worthwhile economy in time as well as money. To do this required the designing of new and original equipment.

A framework of heavy timbers was constructed upon the aft end of a large barge, extending five ft. over the stern. A rectangular frame made of 8-in. angle iron I-beams was fitted into the timber framework, and a roller of 4-in. steel shafting equipped with bearings mounted on the lower side of the rectangular frame. Approximately 15 ft. from the aft end of the barge another roller of similar design was mounted on a movable frame. The heavy timber framework was then bolted to the deck of the barge and from this, by means of a three-way swivel, was suspended the angle-iron rectangle. A cradle, constructed of two 8-in. I-beams, was joined by three steel webb-frames, and into this were fitted five oak pieces with grooved centers. When in operation the cradle rested on the two rollers and inclined at an angle of approximately 20 degrees. The cradle was so installed that it could be rolled out 15 ft. beyond the aft end of the barge.

In making the replacements the old pipe was raised to the surface of the bay, torch cut, and the uncorroded end of the pipe clamped to the lower end of the cradle, a 20-ft. length of new pipe being placed on the upper end. The new pipe was of the screw-joint type, and in making up the couplings a river sleeve, a combination river clamp and coupling, was employed. Upon completing a joint, the checks on the cradle were released and the barge moved forward. The barge was moved from under the pipe until the end of it was within 24 in. of the vessel's stern. During this procedure the cradle moved beyond the stern of the barge approximately 20 ft. and was held in place by a clamp that secured the pipe rigidly in the cradle. The movement of the cradle was controlled by use of a split line with hooks on either end that were fastened into eyes on the far end of the cradle and run up over a block in the head of the A-frame to a small hand winch on the stern of the barge. When the barge was moved from under the pipe a band was placed around the latter and the pipe and cradle lifted some 12 in. clear of the rollers. By taking a slight strain on the hand winch controlling the split lines the clamps were released, the cradle lowered onto the rollers and pulled forward. The pipe was then lowered into the cradle and the rear clamps made fast. A length of new pipe was placed in the cradle



Above: New W-K-M Model "C" Pipe Cleaning Machine on 8-inch pipe.

Right: New W-K-M Model "C" Pipe Cleaning Machine cleaning pipe in the ditch.

For Short Reconditioning Jobs

The NEW W-K-M PIPE CLEANING MACHINE (Model "C" Patented)

THE new W-K-M Model "C" Traveling Type Pipe Cleaning Machine is a small, power-driven unit designed for jobs too small to justify the use of the large W-K-M Model "B" Pipe Cleaning Machine. The Model "C" machine is flexible, and well adapted to cleaning pipe in and around all obstructions, such as valves, patches and clamps. It is ideal for reconditioning those hot spots. Can be equipped with knives for removing old coatings; cutters for cleaning dirt and rust; or a brush head for thorough brushing. It is light in construction, and two men can apply or remove it in less than five minutes. Speed of travel depends on condition of pipe, and varies from 2 to 10 feet per minute. Full details will be supplied on request.

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and the threads made tight. The rubber-packed joints in the couplings were then tightened and a hot enamel coating, reinforced with a heavy gauze-type wrapper, applied to that portion of the pipe that necessarily had been left bare until the coupling was in place. After the final length of new pipe had been lowered, it was tied-in to the original line. This operation had to be done by a diver underneath the water.

During the year the Gulf Pipe Line Company and the Humble Pipe Line Company instituted a new procedure in laying a new line inside of an old one across the Houston ship channel.[6] These, of course, were separate jobs and both were successful. Rather than raise an old line, buried 40 to 45 ft. below the bed of the channel, it was decided that the cost would be considerably less and the work accomplished with greater speed and convenience, if the new line were simply forced through the old one. The Gulf Pipe Line Company's job involved the running of a string of 8-in. pipe through an old 12-in. line, while the Humble placed a 6-in. line inside an old 10-inch.

The procedure on both jobs was to cut the old line a short distance back from each side of the channel and run the new pipe through. On the Humble job the crossing was laid out in 200-ft. sections. As each section was forced into the old line by means of a small tractor a new section was welded on and the procedure continued until the entire crossing was in place, whereupon each end of the line was tied-in. In order to prevent the new pipe from catching on any obstruction on the inside of the old line, a rounded plug was placed on the front end of the first section. The new line also was greased and the old line was kept filled with water to buoy up the incoming pipe.

It is quite uncommon that in construction of a pipe line consideration has to be given to the possible effect of earthquakes on the line and provisions made to guard against serious damage from that source; however, in the case of the Standard Pipe Line Company's recently-completed line from the San Joaquin Valley to Estero Bay such provisions were necessary. Where the line crosses the San Andreas fault the pipe was left above ground for a distance of more than 400 ft., which it is believed will provide sufficient slack to prevent breakage should the earth shift. Also on all new tankage earthquake-proof gate protection was provided by building reinforcements to the gates flanged to the shells.

Station Practice[7]

The trend in field and trunk gathering stations for crude oil continues toward the use of small, flexible units. Readily movable gas and gasoline engines, electric motors and Diesels, have largely replaced steam power. Pumps are both of the centrifugal and reciprocating type. These units are advantageous in that they can be economically installed and readily removed when production plays out. They also can be placed at strategic points in the field to gather the crude from lease tanks, in this manner reducing the loss of oil that occurs in multiple-steam-pump settings, and avoiding the rather heavy maintenance cost involved in the use of a large number of steam pumps.

Gasoline Lines

One gasoline line of major proportions was constructed during the year, that of the Cimarron Valley Pipe Line Company extending from Enid, Oklahoma, to Superior, Nebraska. A factor of interest in the line's construction was the new-type gate valves installed.[8] The valves are designed to eliminate friction incident to opening and closing, and employ the principle of the lever rather than the wedge, the former being frictionless. The lever is utilized to open the valve as well as close it, and acts by first lifting the valve off the seat and then moving it to one side of the opening.

Welding

Improvements in welding procedure have been directed toward increased economy, greater speeds, and improved quality of welds. The Lindeweld multi-flame[9] method has resulted in increased speeds and a saving in rod and gas consumption. A special trimming and beveling machine that makes possible the cutting up of pipe and the beveling of the edges all in one operation has been of great assistance in connection with the taking up and relaying of old lines.

An important recent development of arc-welding equipment is a remote control device that permits the operator to regulate welding current without use of extra cables or rheostat. An idling device that slows down the engine automatically 30 seconds after the arc is broken is another piece of equipment of great value.

Both the oxy-acetylene and the electric methods of welding are discussed more fully in this issue of *The Petroleum Engineer*. (See articles beginning on pages 88 and 110).

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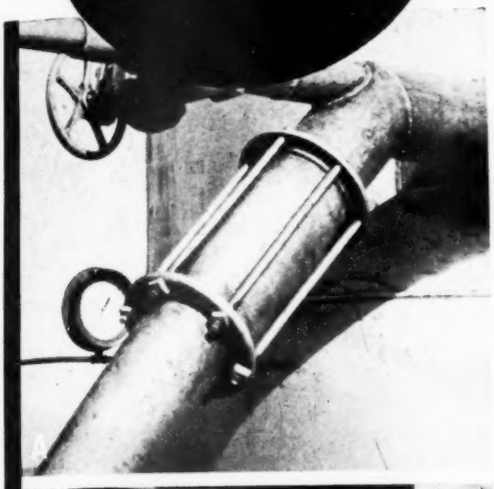
Repairing pitted pipe by spot welding

Hook-ups FROM WELL TO SEPARATOR



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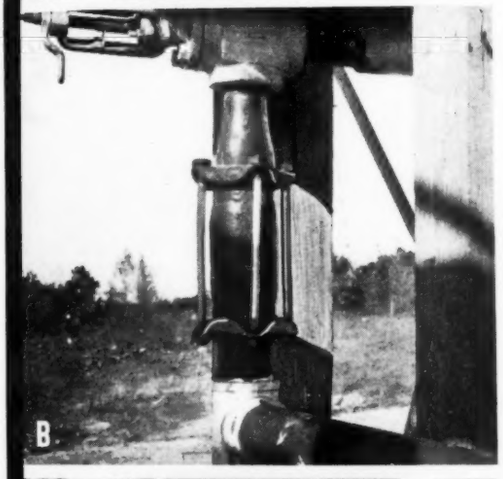

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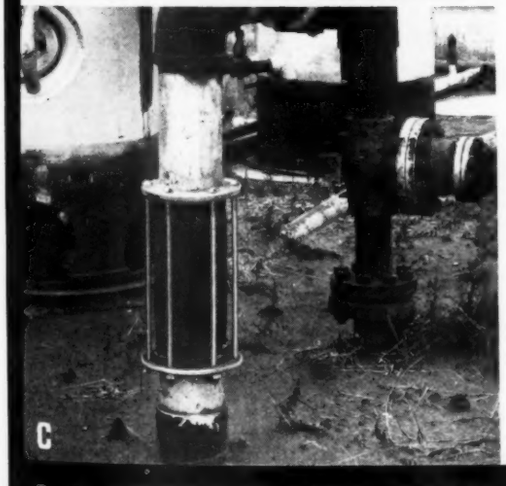

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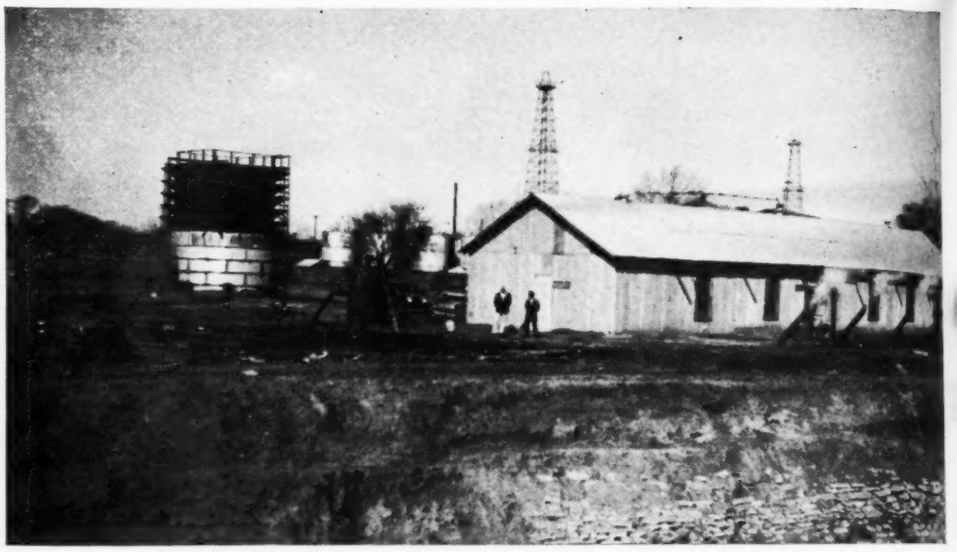
Wells in the Bonyslaw field, Poland, produced by swabbing

By
S. F. SHAW
Consulting Engineer

Review of Gas-Lift Operations in 1934-1935

GAS-LIFT operations during the past year have increased to an appreciable extent over the previous year, owing to the increased demand for oil and to the natural flowing conditions in flush fields. This transformation from natural flow to gas-lift in the Oklahoma City field has been very marked during the past year. There has also been a gradual increase in air-lift operations in the East Texas field where there has been a slow but unmistakable decline in the reservoir pressure.



Compressor plant with 90-hp. units in the Oklahoma City field

Gas-lift is widely employed in California fields for bringing in wells that refuse to flow naturally. Fields in which this practice has been followed include Dominguez, Edison, Elwood, Huntington Beach, Long Beach, Mountain View, Playa del Rey, Rincon, Santa Barbara, Santa Fe Springs, Seal Beach, Ventura Avenue, and West Coyote fields.

In the Big Lake field, Texas, where wells have reached a depth of 8500 ft., the gas-lift is being employed to advantage after natural flow ceases. In the Binger field, Oklahoma, the Denver Producing and Refining Company is lifting oil with gas-lift from a depth somewhat greater than 10,000 feet.

The air-gas lift in its various arrangements is giving good service in some areas in Poland, in which country swabbing at high cost is largely employed for producing deep wells. It might appear that intermittent flow could be employed here to advantage for this purpose.

In Trinidad, gas-lift continues to fulfill its proper function as a link between flowing and pumping. Various forms of intermittent gas-lifts are in use in the island.[1]

In Germany, the gas-lift is being employed to a slight extent, while in Rumania the scope of operations has been quite extensive.

The methods employed in gas-lift operations continue thus far to be those of continuous flow, periodic flow, and intermittent flow.

Continuous Gas-Lift

Continuous flow is employed for lifting the oil when the maximum production is desired and when there is a large production to be lifted. This method is employed in various fields in California and to a large extent in the Seminole and Oklahoma City fields in Oklahoma.

The study of the proper sizes of casing and tubing advisable to employ in continuous gas-lift flow is beginning to receive the attention that it deserves. The first serious study given to this subject for oil field operations was probably that in the Seminole field, when casings of 8⅝-in. O.D. were employed in the East Earlsboro pool and found to permit the lifting of greatly increased production over that

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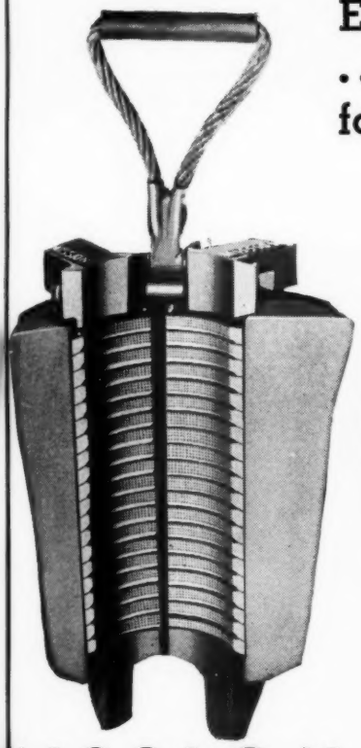

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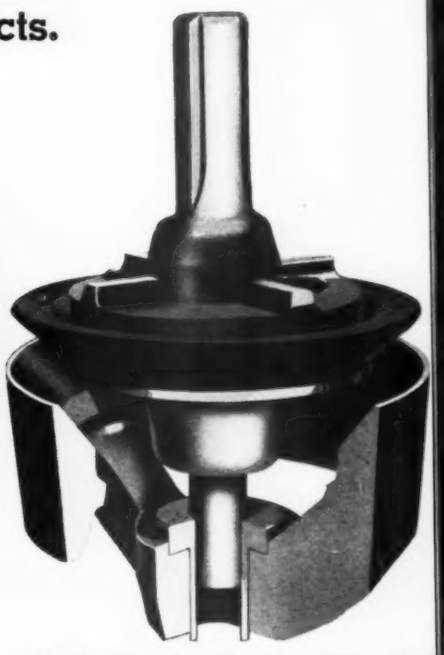

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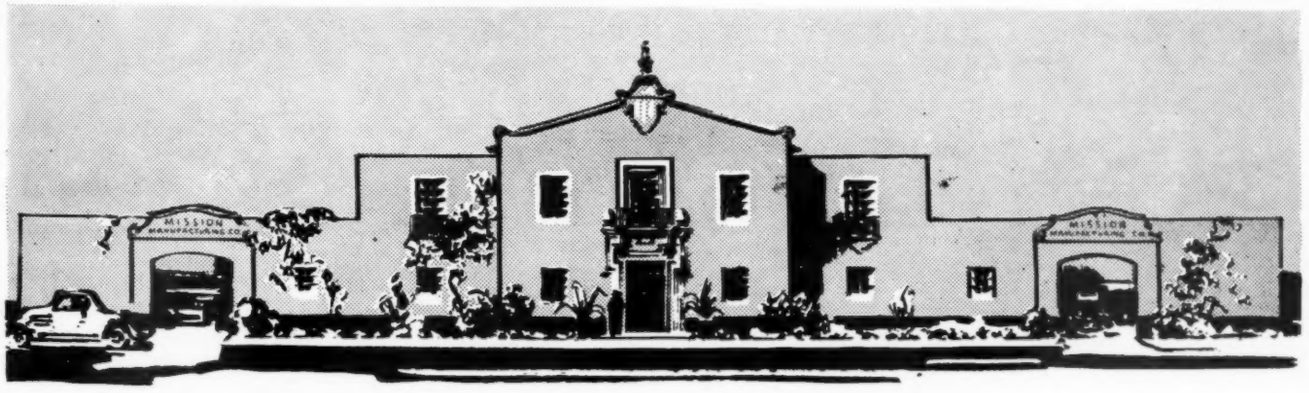

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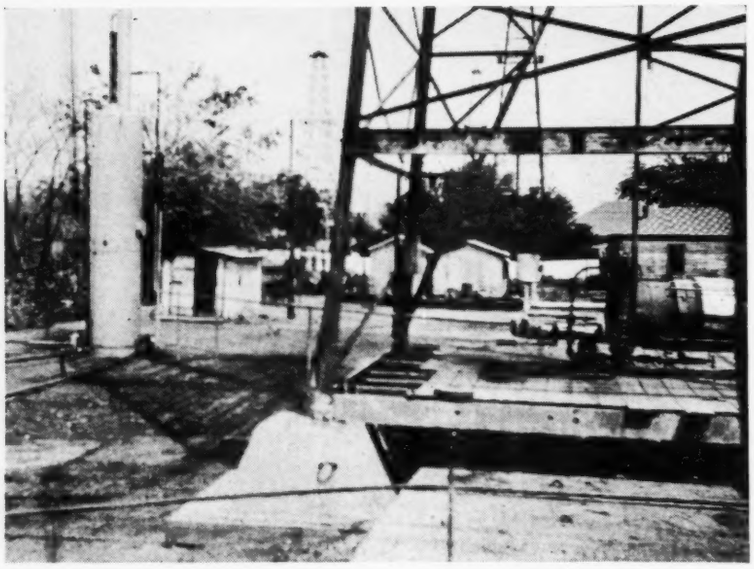


A well at Oklahoma City on the plunger-lift

obtainable in 7-in. O.D. casing, the size commonly employed in that field. The use of 9⅝-in. O.D. casing by the Phillips Petroleum Company and of 9-in. O.D. casing by the Carter Oil Company, Westgate Oil Company and other companies in the Oklahoma City field has shown remarkable improvement in production of oil and in consumption of input gas over the use of 7-in. and 6⅝-in. O.D. casing, the sizes mostly used in the Oklahoma City field.

A comparison between the production recovered to January 1, 1935, with different sizes of casing in certain groups of wells in the Oklahoma City field is given in Table 1.

TABLE 1

Comparison of Quantity of Oil Recovered Through Various Sizes of Casing in the Oklahoma City Field to January 1, 1935

Size of Casing	Number of Wells Included	Initial Production		Bbl. Produced to Jan. 1, 1935	
		Total Bbl.	Per Well	Total Bbl.	Per Well
6⅝-in. O.D.	62	1,724,588	27,816	17,338,000	279,650
7 -in. O.D.	87	2,133,120	24,520	22,902,000	263,200
9 -in. O.D.	7	336,888	48,127	3,534,000	504,807
9⅝-in. O.D.	25	669,834	26,792	14,723,000	588,920

TABLE 2

Recovery Through Different Sizes of Casing for Succeeding Periods of Time in the Operation of Wells in the Oklahoma City Field

Size of Casing	Bbl. Recovered per Well		
	To Feb. 1, 1934	Feb. 1 to Aug. 1	Aug. 1 to Jan. 1, 1935
6⅝-in. O.D.	218,000	32,540	29,110
7 -in. O.D.	204,000	22,600	36,600
9 -in. O.D.	317,206	114,756	72,945
9⅝-in. O.D.	402,760	105,660	80,520

TABLE 3

Consumption of Input Gas in Oklahoma City Wells on Continuous Flow Through Different Sizes of Casing

Size of Casing	Bbl. Oil per Day	Cu. Ft. Input Gas per Bbl. of Oil
Through 2½-in. tubing	565	1,390
Through 3 -in. tubing	888	1,095
Through annular space between 3 -in. and 9-in.	5,928	597
Through annular space between 2½-in. and 9 in.	6,865	570

It might be assumed that production through the 9-in. casing would mean an early exhaustion of oil, to be followed with smaller recovery for a given period of time as compared with the smaller sizes of casing. This, however, has not been the case, as will be observed in Table 2.

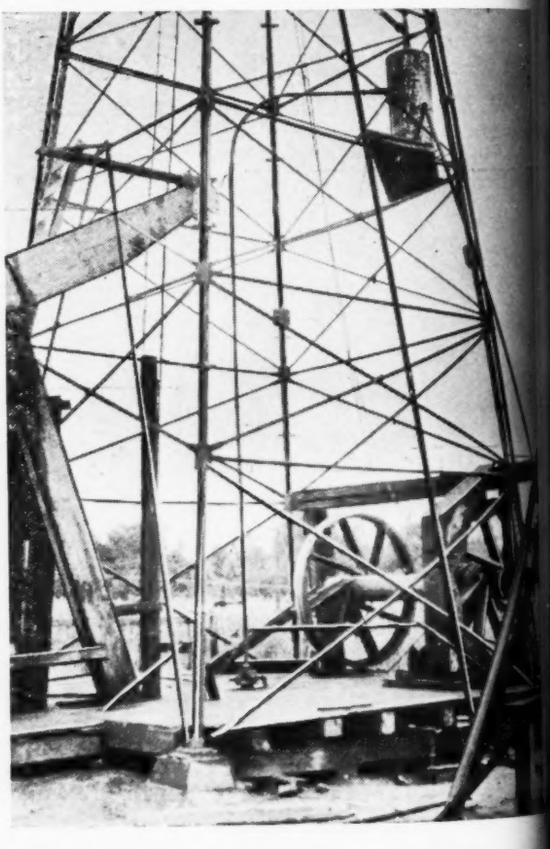
The consumption of input gas in continuous flow has been found to be lower when flowing through large casing in deep wells when compared with small casing,[2] as noted in Table 3.

An important development in the Oklahoma City field has been that of cutting the 6⅝-in. casing at approximately the 5000-ft. point and removing it, thereby providing a "tapered casing" and increasing the size of the flow column in the section where a larger area is most needed, through which the well is produced on continuous gas-lift. Production in these tapered casing strings has been increased from 25 to 300 per cent, or even greater, above that which could be extracted through the 6⅝-in. casing.

Periodic Flow

Periodic flow is being employed in the East Texas field[3] and in the Government Wells field, Texas.[4] In this method the well is opened at periods and flowed for a number of minutes, or hours, dependent on the quantity of oil to be produced per day. In the East Texas field, the capacity of many of the wells is so much greater than the daily allowable production that only a short period is required to lift the oil each day. The wells are then shut in until the following day. The allowable production in the East Texas field averages about 26 bbl. per well per day.

Tubings employed in the East Texas field are usually



A well at Cromwell, Oklahoma, on intermittent gas-lift, using National intermitter

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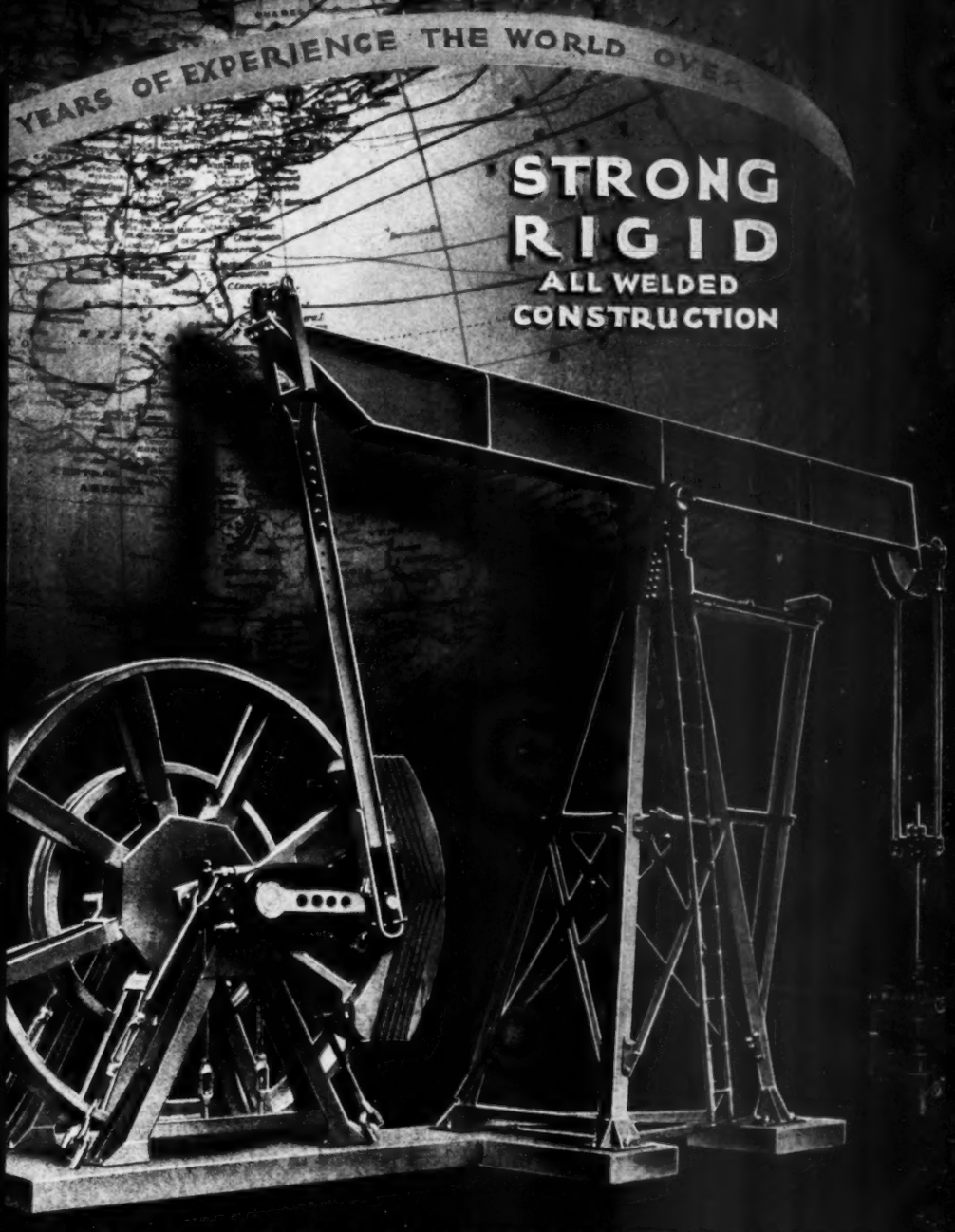

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2-in., or 2½-in., when wells are cased with 5 3/16-in., 6⅝-in., or 7-in. O.D. The wells are usually produced through the tubing. A few wells in this field are cased with 3-in. pipe, and in a few instances the wells are produced through the annular space between the 3-in. and the 1-in. tubing. In the instance of using 3-in. casing, the production is very small compared with larger sizes of casing.

In the Government Wells field, Texas, the wells are opened daily to produce their allowables, and then closed in. Many of the wells flow naturally, but some of them employ gas to start the wells, after which most of them continue to flow their production naturally.

Intermittent Flow

The use of intermittent flow for producing small wells has been steadily increasing.[6] The upper limit at which the use of intermittent flow can be employed is also increasing. In the case of wells in the Oklahoma City field, necessity has brought about a pronounced improvement in the use of this phase of gas-lift operations, such that it has greatly reduced the capital cost of the equipment required for lifting the oil in deep fields, and has also reduced the operating expense to a marked degree.

Intermittent flow in the Oklahoma City field has taken the form of three different types:

1. Introducing the gas through the tubing and lifting the oil through the annular space without any chamber, packer, or valve at the bottom of the well.

2. Introducing the gas similarly to that of the first type, but with packer set between the tubing and casing, and with a standing valve at the bottom of the tubing below the packer. An extension below the packer may be as long as 340 ft., consisting of 4-in. or 5 3/16-in. flush joint casing, with standing valve at the bottom.

3. Introducing the gas through the casing and flowing through the tubing with plunger-lift attachment.

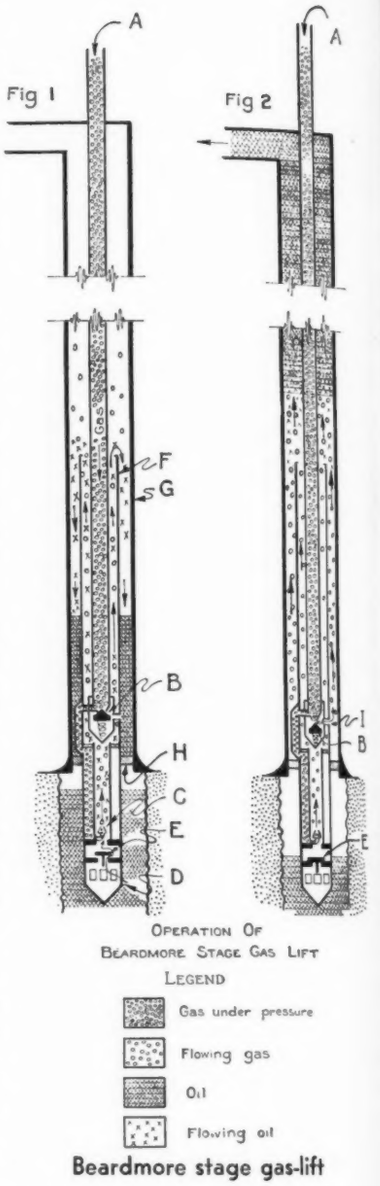
Type 1. Considerable increase in production has been obtained in deep wells by the use of the first method of intermitting. The consumption of gas has been reduced by 10 to 25 per cent, and in some cases as much as 50 per cent.

In shallow wells it is preferable to flow the production through the tubing, but in the case of deep wells, better operating results are obtained by flowing intermittently through the casing.

Type 2. In thick and porous sands, such as those found in the Oklahoma City field, it has been found in some instances that when intermitting the wells through the casing without packer and standing valve, there is a tendency to drive part of the oil back into the sand. To overcome this tendency, wide use has been made of a packer and standing valve at the bottom of the casing, and when the formation pressure is low, an extension is added to the tubing below the packer, thus providing a chamber in which the oil collects between flows. The standing valve is placed at the lower end of the extension. This type of intermitting device is represented by the Clark "bottom-hole intermitter," and the Beardmore "stage lift" in the Oklahoma City field, and there is a fair chance that this method can be employed to advantage in other deep fields. At the present time about 120 Clark intermitters are reported to have been installed in the Oklahoma City field, and about 40 Beardmore stage lifts have been in use.

Intermitting with packer and standing valve has shown increases of 50 to 200 or even 300 per cent in the production of oil above that on continuous flow, and the reduction of input gas has varied from 25 to 50 per cent. An instance is on record where a well with 9-in. casing and 3-in. tubing employing the Clark device is producing at the rate of 350 bbl. per day with consumption of 800 to 900 cu. ft. of input gas per bbl. lifted, with maximum input pressure of 250 lb. when injecting the gas, and with the pressure dropping to 60 lb. at the end of the flow. The consumption of input gas on a group of wells provided with Clark device, averaging 345 bbl. of oil per day, was 1800 cu. ft. per barrel.

An instance is reported of the use of the Beardmore stage lift in a well with 9-in. casing in which the production averaged 605 bbl. per day and the input ratio was 705 cu. ft. per barrel. In one case a small well averaging 15 bbl. per day was intermitted with the stage lift once per day with input gas ratio of 1485 cu. ft. per bbl. of oil.



Beardmore stage gas-lift

Type 3. The third type of intermitting through the tubing with plunger-lift attachment has given excellent satisfaction for small production.[7] In the Oklahoma City field the stage at which it seems practicable to begin the use of the plunger lift is shown in Table 4.

An instance of the use of the plunger-lift for small production is that of the Westgate Oil Company with wells approximately 6500 ft. in depth, in which one 90-hp. gas-engine compressor is handling the operation of three wells making 150 bbl., 85 bbl., and 45 bbl. per day, respectively.

TABLE 4

Stage at Which to Begin Use of the Plunger-Lift in the Oklahoma City Field

Tubing Diam.	Bbl. per Day
2½-inch	100
3 -inch	150
4 -inch	200 to 300

The consumption of gas on plunger lift depends on the quantity of formation gas present. In some cases there is no necessity for addition of input gas. The usual consumption of input gas on plunger-lift ranges from 1000 cu. ft. per bbl. to about 3500 cu. ft. per bbl. in wells of 6500 ft. in depth. Even in wells of 6500 ft. depth it has been demonstrated that the plunger-lift can operate to advantage at pressure of 20 to 30 lb. After flowing pressures have declined below 20 lb. in deep fields, it is probable that no method yet known can be employed profitably at the present time

with oil at $1.00 per bbl; therefore, it would seem that at this time such wells should be abandoned when pressures are reduced below this point for wells of great depth.

The plunger-lift has been found successful in lifting oil in the Big Lake, East Texas, Greta, Pettus, Sugarland, and Yates fields in Texas, in the Elm Grove and other fields in Louisiana, and in the Oklahoma City field. It has also been employed to advantage in a Venezuela oil field.

Starting Valves

When wells are flowed periodically, it is necessary to start these wells with high bottom-hole pressures with some form of starting valve, in order to reduce the pressures that would otherwise be required at the compressors. These valves have been extensively used in the Oklahoma City field, and in the East Texas and Government Wells fields. They are also being employed in scattered places along the Gulf Coast.

An impression has been held that the use of such valves can be made to flow wells successfully after pressures have declined to a low point and thereby reduce the input gas factor. This has not been the experience in the Oklahoma City field, where it was found desirable to remove the valves as soon as they were no longer necessary for starting wells.

Among the valves that have been employed for the purpose of starting wells are the Boynton, Bryan, P & T, Simmons, Taylor and Williamson, as well as home-made valves.

Bottom-Hole Pressure Observations

The observation of bottom-hole pressures both in flowing wells and in closed-in wells has continued through the year, and an understanding of this important subject is gradually being evolved.

Reservoir pressures are summed up at certain periods in various fields, including Conroe, East Texas, Government Wells, Greta, and Rabb Ridge, in Texas, and in the Crescent, Fitts, Keokuk Falls, Lucien, and Oklahoma City fields in Oklahoma, and from these summaries valuable operating data are derived. In Trinidad it is reported that bottom-hole pressure determinations have passed from the experimental stage to a matter of routine in one company and quarterly surveys are undertaken regularly of the more important producing wells.[1]

In wells where there is a high bottom-hole pressure, or in wells that are not tubed, it is preferable to use the bottom-hole pressure bomb for making observations. In wells that are tubed and where there is a high-pressure gas line connected with the well, it is more convenient to inject sufficient gas to displace the oil from the well back into the sand, and then observe the pressure on a test gauge at the well head. The gauge pressure plus the weight of the column of gas determines the reservoir pressure. This method is being used to some extent in the Oklahoma City field.

Compressor Equipment Employed for Gas-Lifting Oil

In fields where gasoline extraction is carried on, it is often the case that gas-lift operations are combined with gasoline extraction. For this purpose it is customary to use direct-driven gas-engine compressors, in units ranging from 165 to 230 horsepower. Also in deep wells where large compressor capacity is required and where ground space is valuable, it has been the custom to use the large compressor unit.

With the introduction of intermitting and of the plunger-lift, it has been found that the smaller compressor units of 60 to 125 hp. are more flexible both for use on a given lease, and for being transferred from place to place. The use of a large unit, even in the Oklahoma City field, is awkward when only a few wells are to be handled on plunger-lift, since the large unit has so much larger capacity than is required.

The makes of compressors employed in the Oklahoma City field are the Clark Bros., Cooper-Bessemer, Ingersoll-Rand, Miller, and Superior makes. A few compressors are driven by electric motors, but by far the greater number are direct-driven from gas engines.

With the exception of gasoline plant equipment used for gas-lift work, the compressor units in the East Texas field are of the small size, ranging from 50 to 125 horsepower. The principal makes in use are the Chicago Pneumatic, Gardner-Denver, and Ingersoll-Rand compressors. A majority of the small units are direct-driven gas-engine compressors. A few units are in use belt-driven from gas engines, and at least one installation is known of a small unit belt-driven from an electric motor.

In the Government Wells field there are as yet few compressors in use inasmuch as gas is available from gas wells under sufficient pressure to start the wells flowing, after which most of the wells flow naturally.

Present and Possible Future Trends in Gas-Lift Production

For handling wells on gas-lift, especially those in fields of considerable depth, the procedure at present appears to be about as follows:

1. Use of natural flow as long as possible, or as long as the desired quantity of oil can be produced in this manner.

2. Use of continuous, or "straight" gas-lift flow until the production declines to a low point, or until the consumption of input gas becomes excessive.

3. Use of intermittent flow; in shallow wells, through tubing with chamber at the bottom; and in large and deep wells, through the casing with packer, extension chamber, and standing valve at the bottom of the well.

4. Use of the plunger-lift at the point where intermittent flow as outlined above ceases to be satisfactory.

Wells in the Oklahoma City field are being carried to the point of abandonment in following the above program, and it would appear as if the same procedure might be found to serve the purpose in many other deep fields.

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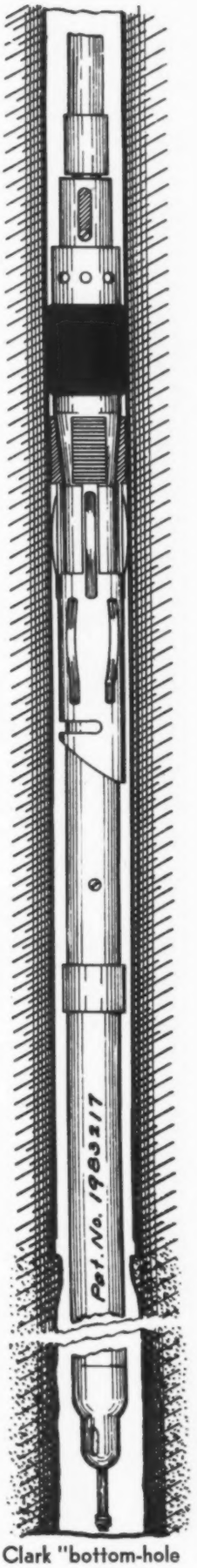
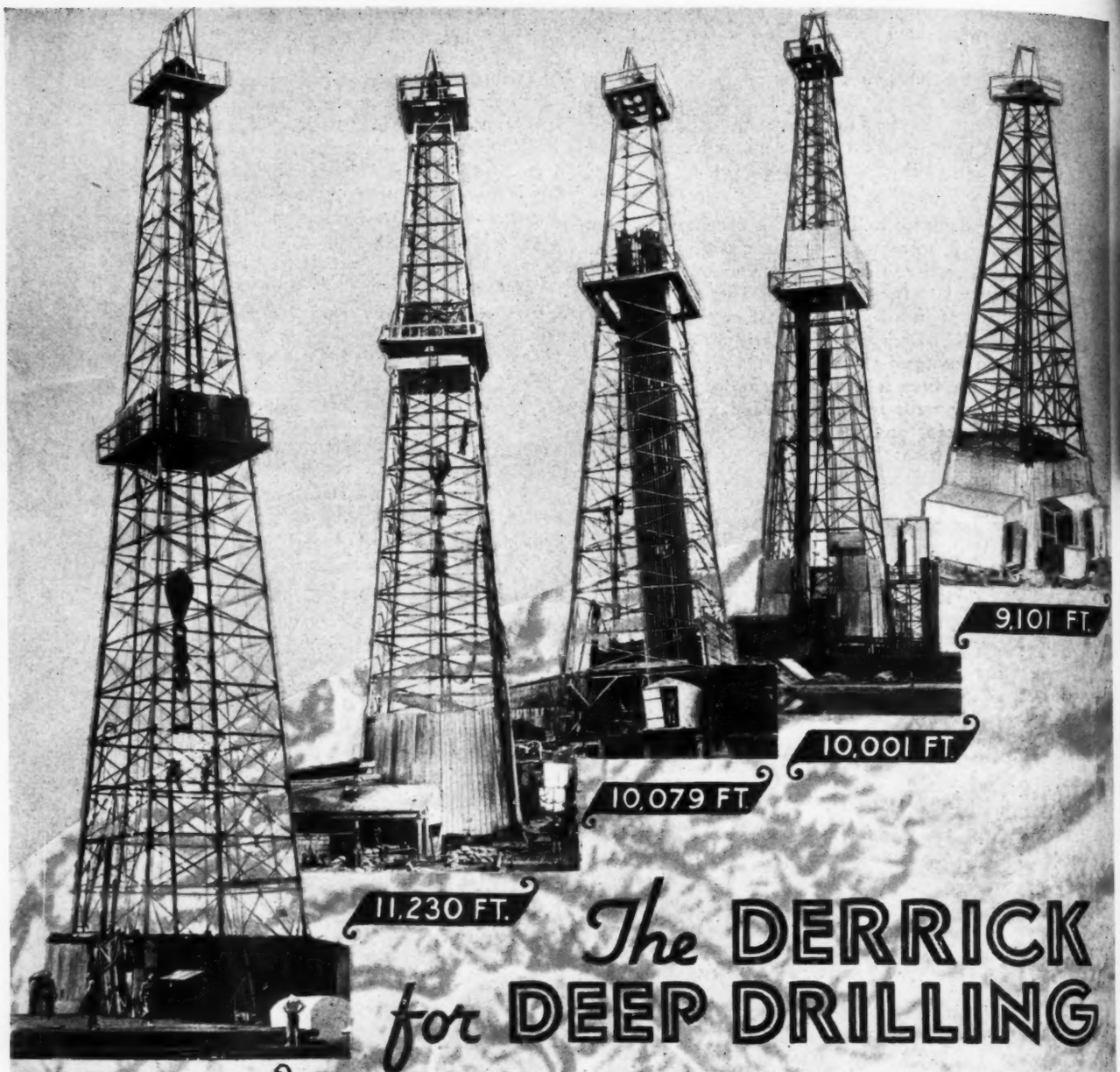


Clark "bottom-hole intermitter"



The DERRICK for DEEP DRILLING

12,240 ft.	World's record rotary well, McElroy No. 103, W. Texas; Parkersburg 136-foot derrick.
11,230 ft.	World's deepest producer, Binger, Oklahoma; Parkersburg 122-foot derrick.
10,079 ft.	Preston Culp No. 6, Okla.; Parkersburg 122-foot derrick.
10,001 ft.	Deep test in Jefferson Davis Parish, Louisiana; Parkersburg 136-foot derrick.
9,101 ft.	World's deepest cable tool well, Frozen Camp, W. Va.; Parkersburg 87-foot derrick.

More and more are operators appreciating the fact that on exceptionally deep tests they play safe when they use Parkersburg derricks.

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A view taken from a plane of the Oklahoma Natural Gas Company's Kellyville Compressor Station. The Devonian gasoline plant is shown at the left. The camp site is in the wooded section at lower left

Review of Gas Lines and Compressor Station Development

By ROY W. PARKER, Oklahoma Natural Gas Company

INTRODUCTION

THE pipe line industry was featured the past year by moderately active construction work in the oil branch and a rather poor showing in the natural gas branch. Inability to finance proposed projects as has been the condition the past three years, was again the primary factor in preventing more extensive undertakings in the gas industry; however, in spite of curtailed construction activities, natural gas progressed considerably in 1934 and 1935. Several important fields have been developed particularly in Texas and Michigan. There were 49 natural gas wells completed in Michigan in 1934, with a combined daily open-flow production of 147,250,000 cubic feet. In a U. S. Bureau of Mines survey it is estimated that the Michigan Stray Sand formation, containing the gas, embraces about 1,350,400 acres, while the proven area is only 18,700 acres. Sales increased 13.7 per cent and revenues 4.5 per cent for the first ten months of 1934, which indicates an increased load factor in the established systems.

LINES

The major pipe line progress report appearing in each issue of *The Petroleum Engineer*, lists the more important projects for the past year. A review of this report reveals many miles of extensions to the various properties and a few main lines of considerable length and size. In the latter group the following could be listed:

The American Michigan Pipe Line Company: 55 miles of 8-in. from the Mecosta pool to Muskegon, Michigan, which was reported completed in December and tested at 400 lb. pressure. This is the longest line in Michigan.

Seventy miles of 12-in. line from the Long Lake field in Texas to the Lone Star System at Riesel Junction, near Waco, was completed in December.

The Sabine Valley Gasoline Company completed 90 miles of line, 2-in. to 20-in., that gathers and transports gas from 900 gas wells in the field near Longview, Texas.

The Southern Natural Gas Company constructed 20 miles of 6-in. from Aberdeen, Mississippi, to their main trunk line near West Point, Mississippi. The rock pressure of wells in the Amory field is reported to have dropped from the original 500 lb. to 25 lb. and this tie-in insures gas for Aberdeen.

The Kentucky Public Service Company laid 126 miles of line from the Sonora field to Elizabethtown, Ky., with several laterals extending to other cities in that territory.

Forty miles of line was laid from the Chittim wells, near Eagle Pass, Texas, to the Texas Gas Utilities' main trunk line that serves the Winter Garden district of the Rio Grande Valley.

COMPRESSOR STATIONS ERECTED

Increased pressure requirements necessary for larger volumes the past year were, in most cases, taken care of by utilizing the reserve well pressures, or adding new wells of higher pressures; however, several companies found it necessary to construct compressor stations to facilitate delivery of larger volumes of gas for greater distances.

The United Gas System, Houston, Texas, installed a compressor station near Woodlawn, La., in the Iowa field. Two

ANOTHER GREAT ADVANCE IN

OVER 500 miles of pipe line has been Lindewelded with the new Multi-Flame Lindewelding Head since the first of the year—and every mile is operating successfully today.

What It Is—And Does

Essentially, Multi-Flame Lindewelding involves three factors—the Multi-Flame Lindewelding Head; a special flame adjustment (employing a backhand technique exclusively); and a special welding rod. The Multi-Flame Lindewelding Head consists of a special chromium plated tip that has three flames: the main welding flame, and two auxiliary smaller flames located about 1¼ - in. from the end of the tip. These two smaller flames preheat both edges of the vee ahead of the point of welding. An excess acetylene flame carburizes the base metal surfaces just ahead of the advancing puddle. The special welding rod perfected for Multi-Flame Lindewelding insures the highest physical properties in the weld metal. The combination of these three factors has resulted in greater speed and economy in the production of pipe welds over previous methods.

Used By Men Who Know

Over one hundred experienced pipe line operators have already used the new Multi-Flame Lindewelding Head on hundreds of miles of pipe line. The strongest proof of their unqualified acceptance is found conclusively in the fact that the new Multi-Flame Lindewelding Head, which had its inception in the mid-continent field, has entirely superseded the single flame for all Lindewelding of pipe lines in that territory.

Proved Under Actual Conditions

In the heart of the mid-continent field, under the most adverse and grueling operating conditions, Multi-Flame Lindewelding literally went through a baptism of fire and emerged a perfected and accomplished technique. Here, this modern technique was tested, improved and rigidly retested with but one objective—to fill the industry's demand and need for more speed and economy in consistently producing good welds.

Saves Time, Rods and Gases

The enthusiastic acceptance of Multi-Flame Lindewelding by pipe line companies and contractors is due to its outstandingly greater speed, economy and ease of operation. It meets all field welding conditions, any size pipe, and wall thickness, jammed joints, excessive spacing, and high-low line-ups. Yet, important as these advantages are, the dominant fact is that with *the new Multi-Flame Lindewelding Head and the proper technique,* the average pipe line operator can effect *savings ranging from 15 to 40 per cent in welding time, rods and gases.*

Linde Process Service Cooperates

There need be no hesitancy in adopting Multi-Flame Lindewelding on your pipe lines. If you use Linde Oxygen, Linde Process Service Operators will help you organize your welding operations to secure the greater speed, efficiency and economy now possible with Multi-Flame Lindewelding. The development of Multi-Flame Lindewelding has conformed with the non-compromising standards set by Linde engineers since oxy-acetylene welding was first adopted for pipe lines. Standards that automatically require the work of development to be carried on in both the laboratory *and under actual operating conditions in the field.*

Lindewelding Performance Told in Pictures

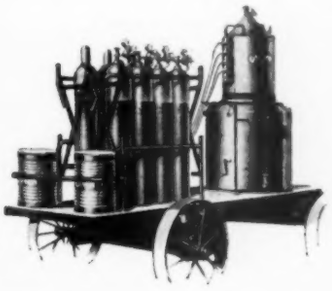
RECORD RIVER CROSSING—With Multi-Flame Lindewelding this 8-in. line was laid across a river in one day—a notable record.

TIME IS MONEY—With Multi-Flame Lindewelding a saving of 25 per cent in welding time was made on this 10-in. pipe line.

89 WELDS PER MAN DAY—On a stretch of 6-in. line a record of 89 welds per man day was achieved by men with little previous experience with Multi-Flame Lindewelding.

FIFTY PER CENT INCREASE IN PRODUCTION was achieved on this 8-in. line. Six men averaged 304.6 welds per day with Multi-Flame Lindewelding.

You can order everything for Pipe Line Welding from Linde



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PREST-O-LITE ACETYLENE ... ready to use—the standard dissolved acetylene for well over a quarter of a century.

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UNION CARBIDE... sold in the familiar Blue and Grey drum from over 250 warehouse stocks.

PIPE LINE CONSTRUCTION

Contact the Nearest Sales Office

The nearest Linde Sales Office will be glad to furnish complete information on Multi-Flame Lindewelding and the cooperation extended by Linde Process Service. Offices are located at Atlanta — Baltimore, Birmingham, Boston, Buffalo, Butte—Chicago, Cleveland—Dallas, Denver, Detroit—El Paso—Houston—Indianapolis—Kansas City—Los Angeles—Memphis, Milwaukee, Minneapolis—New Orleans, New York—Philadelphia, Phoenix, Pittsburgh, Portland, Ore.—St. Louis, Salt Lake City, San Francisco, Seattle, Spokane and Tulsa.

Everything for oxy-acetylene welding and cutting—including Linde Oxygen, Prest-O-Lite Acetylene, Union Carbide and Oxweld Apparatus and Supplies—is available from Linde through producing plants and warehouse stocks in all industrial centers.

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PERFORMANCE TELLS THE STORY

FIFTY Per Cent Increase in Production was possible with Multi-Flame Lindewelding on a line of 30 miles of 6-in. pipe with $\frac{5}{16}$-in. wall, and 24 miles of 8-in. pipe with $\frac{1}{4}$-in. wall. Multi-Flame Lindewelding was not available until after 14 miles of the 8-in. line had been welded. The remaining 10 miles of the 8-in. line was completed in three more days with Multi-Flame Lindewelding. This resulted in an average of 304.6 welds per day for six men which represented 50 per cent increase in production with no increase in personnel. Test welds were cut from the lines and given the reverse bend test. No welds failed in this test. This marked increase in production made the use of Multi-Flame Lindewelding on the longer 6-in. section a matter of course. The pipe was in 40-ft. lengths with 37½ deg. bevel. On this part of the line the six men averaged nine welds each per hr., or an average altogether of 4 miles per day in spite of sand and long moves. The line tested with 100-lb. air pressure proved absolutely tight.

Cross River in One Day. Another 8-in. line gives some further comparative data. The pipe lengths averaged 18 ft. and the weight of the pipe was 24 lb. per foot. The pipe in this case was from an old line and had been reclaimed by means of a pipe-cutting machine. Six welding operators were employed, four using the ordinary single flame blowpipe while two used the new Multi-Flame Lindewelding Head. The latter two attained a speed of 50 welds each per day, the former making but 40 welds each, or an increase of 25 per cent for Multi-Flame Lindewelding. One interesting section of this particular job was a 1500 ft. river crossing. By using special construction methods and Multi-Flame Lindewelding, the crossing was made in one day, a notable record.

Record of 89 Welds per Man Day. A prominent contractor of the mid-continent field has installed a number of lines with Multi-Flame Lindewelding. In one instance 30 miles of new 12-in. pipe were laid in 11 days. Considerable delay was experienced due to the nature of the country and river detours, so that several days were not worked full time. The six men on the firing line were averaging 30 or more welds a day even with these handicaps, and one day averaged 36.5. On a stretch of 8-in. pipe the same men averaged as high as 48 welds each per day, and on 6-in. pipe a record of 89 welds per man day was attained. Both 6-in. pipe and 8-in. pipe were $\frac{13}{64}$-in. wall thickness, second-hand and beveled by a blowpipe cut. None of these welders had had much previous experience with Multi-Flame Lindewelding.

Saves 25 Per Cent in Welding Time. Still another contractor has been doing considerable work on 10-in. pipe of $\frac{13}{64}$-in. wall thickness. On a 42-mile line laying new pipe in 40-ft. sections an average of approximately 38 welds per man day was obtained. There were four men on the firing line, each working on a string of five 40-ft. sections. The record made on this line with Multi-Flame Lindewelding represented a saving of 25 per cent in welding time over the older single flame tip.

major buildings house ten compressors with a total of 1700 hp. Residue gas is taken from the Shell Petroleum Corporation's natural gasoline plant and delivered through eight miles of 8-in. line. The intake pressure is about 40 lb., which is increased to 400 lb. for delivery into the United's main line from Texas that serves southwestern Louisiana. The station has a capacity of 11 million cu. ft. daily.

Another station was built by the Kettleman North Dome Association in the Kettleman Hills field of California. This station has six compressor units capable of handling 12 million cu. ft. daily and will increase Kenda's capacity to 22 million cu. ft. daily.

Two compressor stations were added to the Kentucky Natural Gas Corporation's system. The stations were necessary to care for the additional loads developed on the company-owned 630-mile line from the gas field in Barren, Hart, Green, and Medcalf counties, Kentucky, to Terre Haute, Indiana.

The Northern Natural Gas Company has installed a booster at Ogden, Iowa. There are three 800-hp., twin-tandem, double-acting, Cooper-Bessemer engines at this station.

The United Gas System has a comparatively new plant at Conroe,[1] Texas. There are ten 160-hp., 3-cylinder Hope Vertical compressor units in this plant. The station is designed for two-stage operation. The gas header arrangement and compressor cylinder sizes permit five units to operate on each stage. Up-to-date and efficient equipment handles the gas on its course through this station.

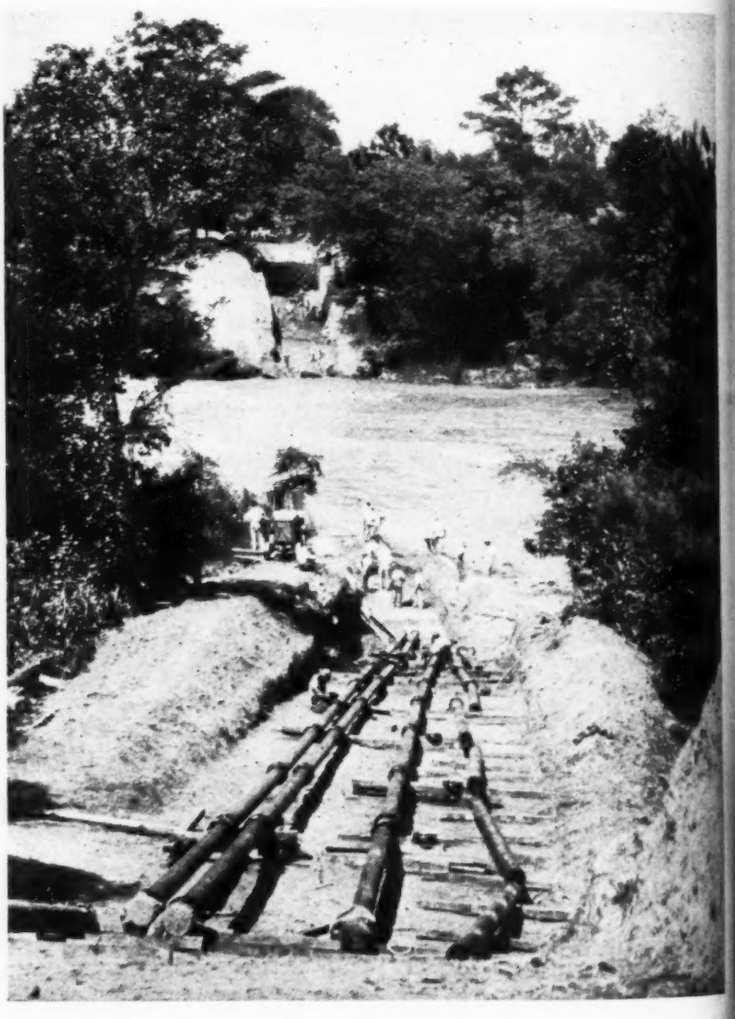
BUILDING DESIGN

The design and construction of compressor stations and auxiliary buildings erected more recently retain all the operating advantages of the older stations but differ considerably in details that tend to increase efficiency and safety. More advanced construction engineering and superior materials are now incorporated in the modern plant. Stations are of structural steel frame, asbestos roofing and are designed to give the maximum of light, ventilation, and conveniences. Those companies operating in the dust area have in all probability realized the necessity for extremely tight buildings during some of the severe dust storms this spring. Modern construction features are typified by the Western Gas Company's main buildings.[2] They are provided with full basements and in each floor a well has been made that permits the traveling crane to place any single piece of equipment directly on a truck driven into the basement. Another feature of new floor construction is the severance of the operating floor from engine foundations, thereby eliminating vibrations.

Good practice calls for the use of reinforced welds in all high-pressure gas lines on the plant site instead of joints. Factory bends are not uncommon in newer stations. Simplicity and modification of all station pipe lines and valves are now cost reduction and safety features of the modern plants. The design and the filtering medium for intake air are being given more attention since many of them proved useless during the severe dust storms. Cooling towers in windy sections have stream-line louvers to eliminate excessive water outage. Many such alterations in building plans have recently been made, each change improving some operating condition.

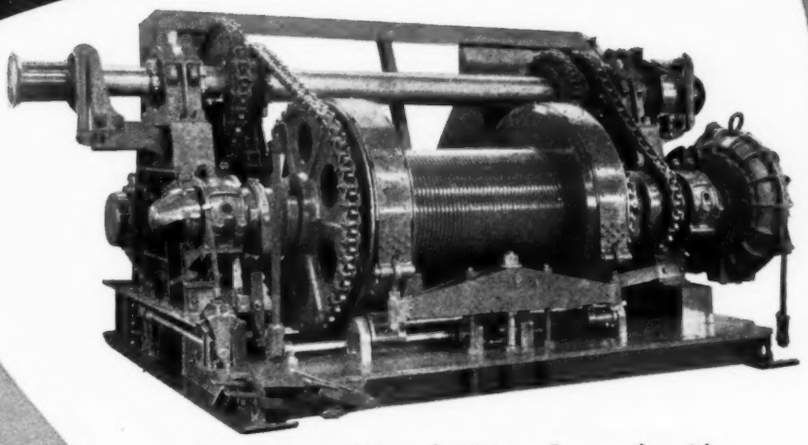
ENGINES

The design of construction and basic principles of operation of large prime movers have not undergone any major changes for sometime. A choice of several types and sizes has been available for several years. The designers and manufacturers of compressor station engines have, however, called upon their technical staffs for modernization, resulting in improved units of the same design. Availability of improved materials has permitted the maker to increase speed and decrease the stroke, both of which have resulted in smaller and more efficient units. More suitable metals and alloys have appeared in valves and valve seats of the engine, increasing their life and reducing maintenance cost. Other features in bearings and bearing metals have been perfected and proved their worth in promoting more efficient operation. New developments have brought interchangeable cylinder liners, plate and feather valves and other devices that permit varying the clearance volume. Solid bearings have been replaced by roller bearings or by two- or four-piece babbitted wedge adjustment bearings.[3] At least two manufacturers of horizontal four-cycle-engine-driven compressor units have made changes in power cylinders to facilitate cooling both the head and valves. Engines with heavier supports, higher compression heads, renewable valve seats, and heavier duty clutches are being used in auxiliary plants. Cylinder honing is now a maintenance feature. Cylinders bored by the manufacturer to a tolerance of .002 to .005 of an inch can be honed to a tolerance of .0005 of an inch. This eliminates the "wearing in



One of the many river crossings necessary to reach a new source of gas

EMSCO



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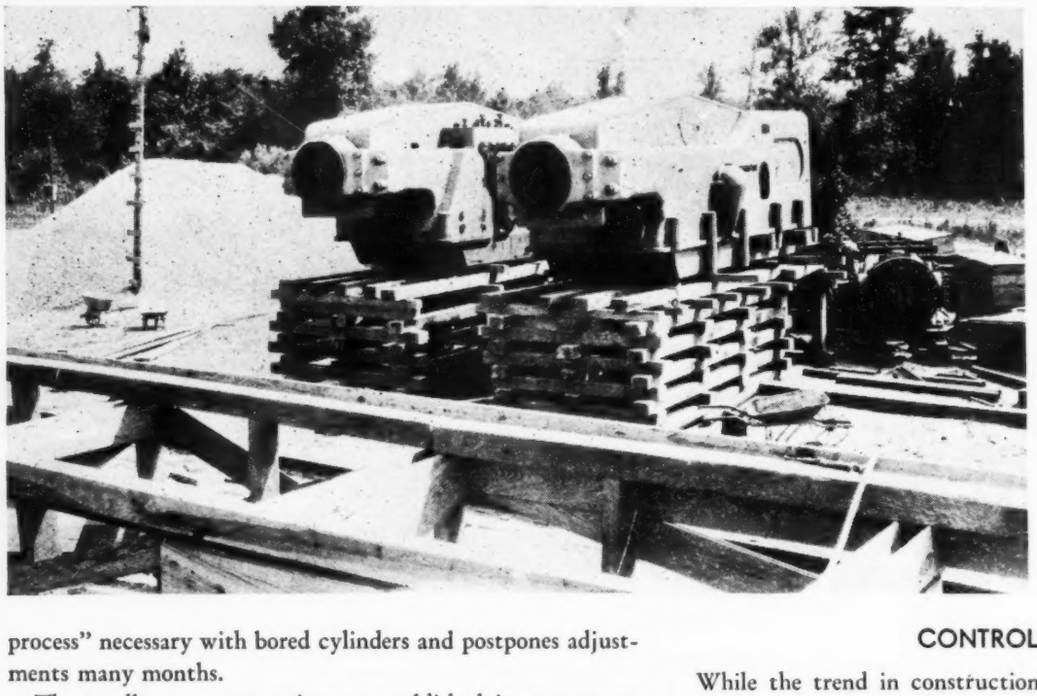

An early stage in the erection of a modern compressor station

process" necessary with bored cylinders and postpones adjustments many months.

The smaller compact units are established in compressor station operation. Formerly, when rock pressures varied considerably in the different sands, it was necessary to shut-in the low-pressure well when the demand on a station required a greater suction pressure than they produced. A common practice now is to tie these low-pressure wells into the suction side of small units in order to raise the pressure to that of the higher-pressure wells. The units are equipped with automatic shut-down devices actuated by high water temperature, high oil temperature, or high pressure to ground magneto and shut engine down. These units are automatic to the degree that very little attention is necessary for their continuous operation. Small stand-by units of the gasoline-motor type are being converted to use natural gas and are replacing some of the standard equipment installed in auxiliaries.[4] These units give a three-fold service to increase the margin of safety against shut-downs during capacity operation: first, in economically meeting the lighter auxiliary power demands of the summer months; second, in providing power while other auxiliary equipment is down for repairs; and third, it is reliable because no air is needed to start, and either gas or gasoline can be used for fuel.

The anticipated work to be done by a station has been a deciding factor in the operator's choice of size, number, and type of equipment. In the Industrial Fuel Company's Huntington Beach station there are 20 two-cycle, power head, 165-hp. engines.[5] This station operates over a range of from 27,500,000 cu. ft. to the lowest amount consumed in distribution sections of the final system. The large number of small units seems best suited for such varying requirements.

All gas is metered at this station as it passes through the various distribution headers, each equipped with twin meters. One is on a 6-in. line and the other on an 8-in. line. The line leading from the plant is 12-in. and as it is being loaded to normal capacity both runs are utilized for measuring. When the demand is small the 8-in. line is cut out by a differential controlled diaphragm valve on the down-stream side. An increased demand permits the diaphragm to open the larger line. This simplifies chart calculation and gives more accurate measurement at low pressures. The plant is equipped with new type air-cooled exhausts. They utilize the force of the exhaust in making a draught of cool air around the exhaust stools.

CONTROLS

While the trend in construction and design of buildings and equipment has not changed materially during the last year, there has been considerable thought given several operating practices to increase safety and make the stations more automatic. Although interrupted service will probably never be entirely eliminated, means are being provided that lessen the possibility or minimize the cost of such occurrences. Provisions are now made in the newer plants for emergency stop equipment in case of fire, explosion, line blow-out, or engine failure.

Remote control, from some source of power, of all plant intake and discharge valves, fuel gas shut-off valves, and plant blow-down valves is one method.[6] This system, used by the Industrial Fuel Supply Co. at their Ventura Station, employs the use of a butterfly valve in each low-pressure line and stop-valve of the swing-check type in the high-pressure line that is operated by a falling weight released by an air-actuated diaphragm. In the fuel lines are balanced valve type stop valves. A blow-down valve is installed in a large main that joins the discharge pipe just ahead of a non-return valve, an arrangement that prevents gas from blowing back into the plant in the event of a broken main. In case of an emergency, these key valves can be closed from a central point and the plant freed of gas in one and one-half minutes.

Explosions have occurred after the compressor station's master fuel gate had been closed because of the fuel line pack and the live ignition. In some plants, combustion air is taken from within the building; if this air should contain sufficient gas or vapor the engines would continue to operate for a short time after fuel valve had been closed.

One emergency stop method is the grounding of the ignition.[7] This remote control is compact, reliable, and inexpensive and will stop several engines simultaneously. Fig. 1 is a sketch of this control. One terminal is grounded and the other is shorted in the low-tension side of the magneto. Connections are made to several emergency stations inside and outside the building to the 1-in. control header. Each carries a quick-

opening valve. Normally the mercury in the manometer is held in contact with one terminal by means of pressure or vacuum. When a quick-acting valve is opened the mercury balances, contact is made and grounds the magneto to stop the engine. Tests have shown complete stops in 8 to 12 seconds under full load. There is no hazard during this time.

COMMUNICATION AND PRESSURE RECORDS

Telephone systems along long transmission lines are looked upon as indispensable. Lengthy and frequent conversations between supervisors and operators are often necessary for proper and economical service. Drops from the main line wires are made at what are considered strategic points. Portable telephone sets are used by the line walkers or trouble shooters to report any trouble immediately.

It has become increasingly important that pressure conditions at vital points on a transmission system be available to station operators at all times. Telemetric recorders that register instantaneous pressures at various terminals insure a more exact and economical service. This enables the operator to have adequate terminal pressure at the lowest outlet pressure, by more frequent governor adjustments. The stations' immediate response to a change in pressure along the line will save considerable fuel gas and decrease leakage, since the maximum load occurs only five or six times a year, and needless packing is eliminated. This type of control also gives an accurate study of the time lag on long transmission lines. Trouble may be experienced from lines freezing in sub-zero weather where they cross rivers or are exposed on bridge crossings.[8] This trouble is not quickly detected when compressors operate automatically, and the line is frequently loading and unloading. The New York Power and Light Company uses a Bristol remote pressure-recording installation that gives the operator a continuous pressure line for any point beyond the troublesome section. This warns him if the station is not operating normally.

RECORDS

Records have a very definite place in compressor station operation. The forms for recording operating data need not be complicated, but sufficiently detailed to express the several factors necessary to get a picture of station efficiency. The several items should define and appropriate costs of maintenance and operation so that they provide the person in charge a ready reference. Comprehensive records are invaluable in preparing budget reports, defining fixed capital, and having rate fixation figures.

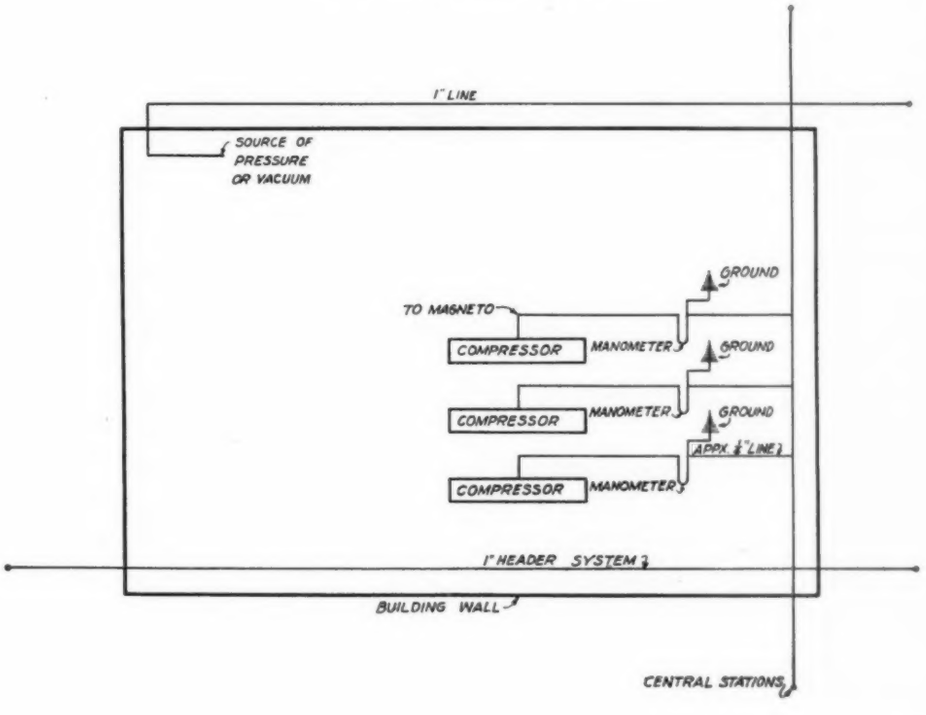

Fig. 1. Diagrammatic sketch of an emergency stop

LABORATORIES

Compressor stations are becoming more technical and scientific in nature. The chemical engineer has taken his place as an assistant in the proper and economical operation of most modern plants. The water supply calls for attention, the lubricating oils must have certain specifications, the gas is analyzed, and many other tests are made that facilitate the correct operation of the station. The laboratory is often called upon to operate and service gravitometric and thermal instruments installed in the plant. Very often the cause of ill-operation, while it may appear to be mechanical, is a chemical problem.

During the past five years, the manufacturers of engine equipment have worked diligently to meet the operators' demands. This coöperation has resulted in better and more adaptable units. If we could see the Clayton duplex gas engine that powered the first compressor station at Rexford, Pa., in 1880, no doubt we would agree that compressor designs and operating practices had kept pace in the development of the gas industry.

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Hydrogen Sulphide (H_2S) in the presence of water has the peculiar property of causing corrosive embrittlement of straight carbon and alloy steels most frequently used for sucker rods. The effect of this embrittling action on ordinary sucker rods contributes to their early fatigue and failure. Grade "S" Sucker Rods have inherent properties to combat hydrogen sulphide embrittlement. Use them in your sulphide wells —and check their performance against all others.

Now You Can Lower Production Costs of Pumping Sulphide Wells!

Shutdowns, delays and replacements caused by sucker rod failures increase your production costs. Accurate service records have been maintained on all Grade "S" Sucker Rod installations to date and their outstanding performance and resultant economy strongly recommends their installation . . . Superior performance makes Grade "S" Sucker Rods the cheapest available.

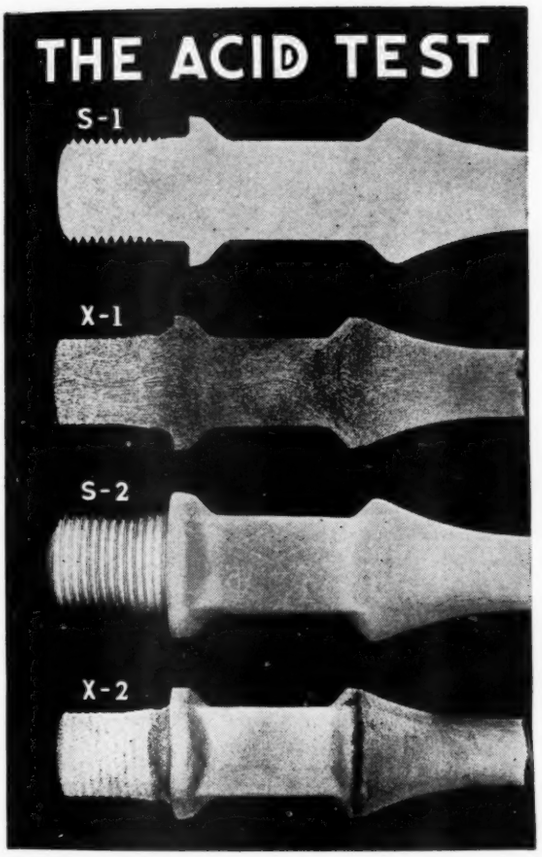
Grade "S" Metal is a Low Metalloid Steel!

It is practically pure clean iron, with slag inclusions eliminated, alloyed with nickel and molybdenum. "OILWELL" Grade "S" Sucker Rods are upset with extreme care by a special process, after which the rods are fully heat-treated, i.e., normalized, quenched and drawn over their entire length, made possible only in "OILWELL's" heat-treating furnace and auxiliary equipment . . . Only by these exclusive methods is it possible to secure the desired balance between strength and ductility, and the required resistance to sulphide embrittlement and corrosion fatigue.

• • •

"OILWELL" engineers and metallurgists recommend Grade "S" Sucker Rods for sulphide wells in installations where the rod stresses are as high as 30,000 lbs. per sq. in.

Grade "S" Sucker Rods for Sulphide Wells



These unretouched photographs show the results of a deep acid etch after 1½ hours in 50% Hydrochloric Acid at a temperature of 170° F. S-1 shows the *center line plane* of a Grade "S" ¾" A.P.I. pin. X-1 shows the plane of an S.A.E. 1045 plain carbon steel. S-2 and X-2 show the *outer surface* of the pins. Note how the threads of the carbon steel have been eaten almost completely away.

Performance records have been established for "OILWELL" Grade "S" Sucker Rods in wells at:

Seminole, Oklahoma
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Voshell, Kansas
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Progress in the Use of Bottom-Hole Chokes

By H. C. OTIS

Southern States Company
Dallas, Texas

DURING the past year the use of bottom-hole chokes as a means of controlling rates of withdrawal from high-pressure wells and of eliminating the freezing that normally would often accompany such operation, has become general throughout the Mid-Continent and Gulf Coast fields. They are now in use in almost all the wells in these areas in which the rate of withdrawal is so low as to result in freezing when surface-choking is employed. When flexibility in the rate of withdrawal is desired, a mixing valve, consisting of a large needle valve controlling withdrawals from the well casing-head, is connected to the tubing riser in such a manner that the hot production from the tubing serves to heat the colder production passing through the mixing valve (see illustration on p. 65). A very considerable range in possible rate of both gas and fluid production is obtained in this manner.

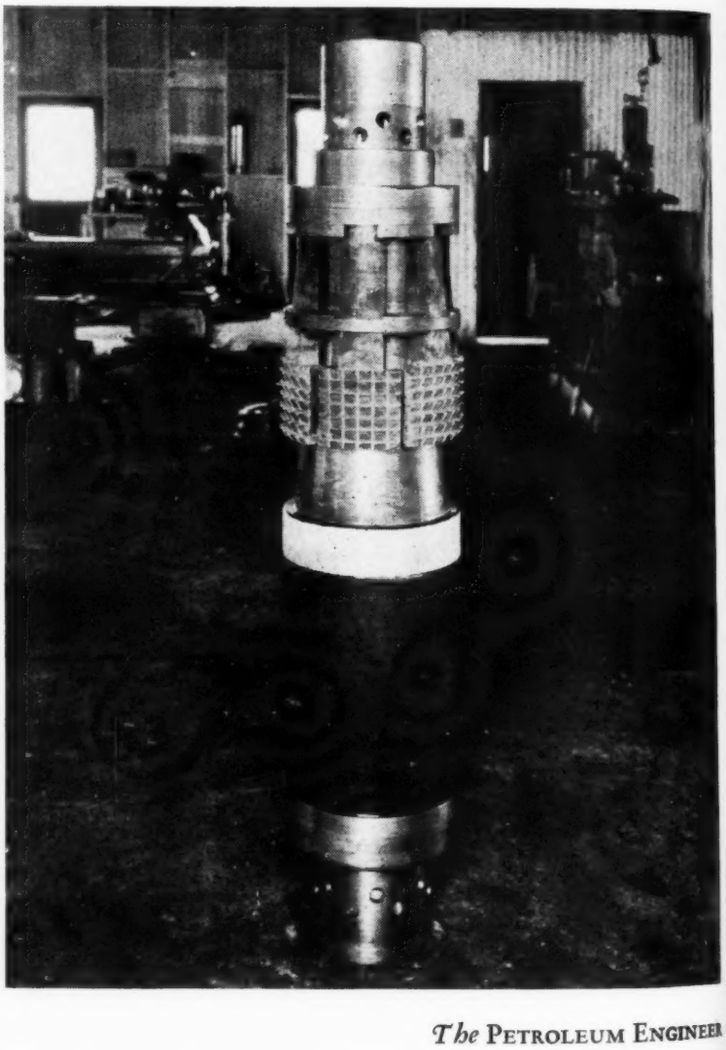
Gas companies operating in high-pressure fields in both the Eastern fields and on the Pacific Coast are now considering this method of well operation, while the Natural Gas Association, in conjunction with the U. S. Bureau of Mines, is preparing to make a thorough study of the matter.

One company has found that bottom-hole choking apparently reduces treating difficulties when producing from a high gas-oil ratio well that produces water along with the oil. In the instance of the well experimented with, approximately two per cent B.S. was going over from the separator when controlling flow through a surface choke. After a bottom-hole choke was installed, only 0.2 per cent went past the separator. It is thought that the higher temperature at which the fluids entered the choke reduced to a certain extent the amount of cutting that took place, but the principal benefits were obtained through the warming effect of the hot production outside the tubing immediately above the choke and due to the tubing itself acting as a long vertical separator. This latter was borne out by the fact that whereas when using a surface choke the consistency of the fluid between the surface choke and separator was fairly uniform, when using the bottom-hole choke, samples taken just before entering the separator would show either pipe line oil or pure B.S. During its flow up the tubing the B.S. had apparently been partly treated out as a result of the higher temperatures surrounding the tubing and had largely separated itself from the oil, thus aiding further separation as it passed through the separator.

During the past year at least three strings of tubing have been extended several feet to the bottom of the well by threading the required amount of small diameter pipe onto the bottom of a removable bottom-hole choke. This operation is entirely practicable where the required amount of pipe is not more than the height of the derrick, where the bottom of the tubing is in such condition that there is no danger of the couplings on the small pipe hanging-up if it is desired to remove this pipe at some later date, and where there is little danger of the small pipe sanding-up. Should there be any danger of the latter two events taking place, a releasing element should be placed between the bottom of the choke and the smaller pipe, so that the choke itself can at any rate be recovered.

Blank removable bottom-hole chokes for plugging pipe have been put to a variety of uses. One company, with flowing production out in the Gulf of Mexico, has so equipped its wells that blank chokes can, whenever a storm warning is received, be quickly run to a depth of a few hundred ft. below the surface. Since the tubing in these wells is landed on a liner seal, with the blank choke in place in the tubing the wells would not be in danger of being opened to flow but would be safely shut-in even though the connections should be knocked off during the storm.

A somewhat similar use for a bottom-hole choke was hit upon by a company in one of the South Louisiana high-pressure fields. This company



Blank removable choke for plugging 12¼-in. hole set in lime rock instead of in casing

rather unexpectedly found that it had a well with a surface pressure of 3200 lb. and with a none too heavy tubing Christmas tree. An oversize bottom-hole choke (¼-in.) was set at 8400 ft. in the tubing simply as a safeguard in the event anything should go wrong with the tubing surface fittings. Were this to happen, the well would not be turned wide open through the fittings, but would instead be restricted to such a low rate of flow that no difficulty would be experienced in stabbing a new Christmas tree onto the well.

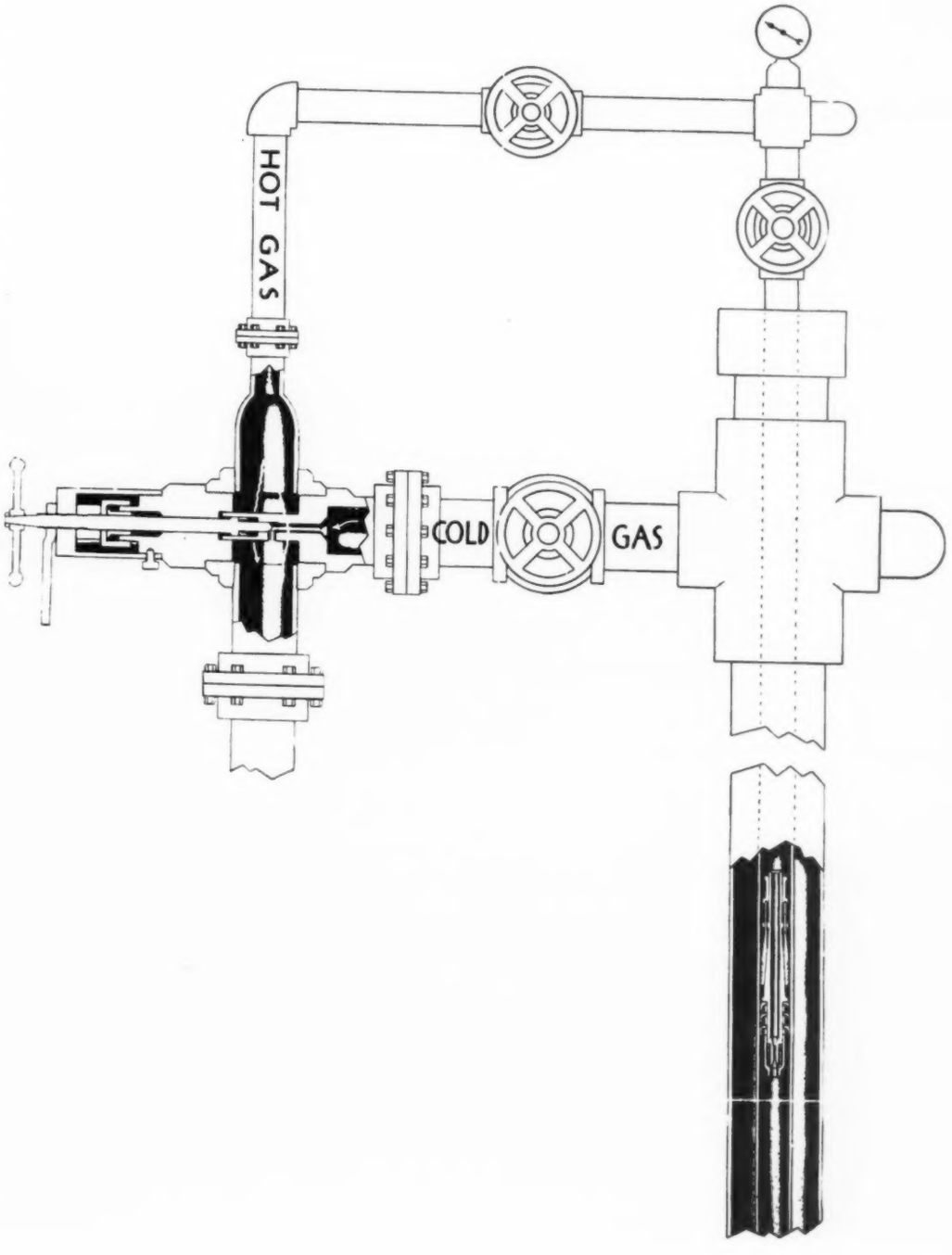
Another company in West Texas, after drilling a 12¼-in. hole into the sand under pressure, set a 12¼-in. blank choke in the hard lime above the pay, ran and cemented 10-in. casing above the choke, then after drilling the plug, simply knocked the choke to bottom and left it there. A 12¼-in. hole into the sand was thus obtained with 10-in. casing set on top of the sand—all accomplished under pressure without any mud reaching the face of the sand.

A few weeks ago a string of 7-in. casing had to be run under pressure into a well in the Jal field of New Mexico. A blank 7-in. choke was set in the first joint of casing to be run into the well. A perfect shut-off was obtained all the way to bottom, and, after the string was landed, the choke was very simply pulled under pressure.

Other uses to which these blank chokes have been put include the plugging of tubing to test the seats in retracting tubing heads, in plugging tubing strings to be pulled under pressure, and in plugging tubing strings above a packer when running the packer under pressure.

The considerable use to which packers have been employed during the past year in high-pressure wells has led to the designing of a packer constructed along the lines of a removable bottom-hole choke, or a packer that, like the choke, will not be moved up the hole when the pressure beneath it is greater than that above it.

Removable bottom-hole chokes were designed and constructed originally for use in prolonging flow in weak oil wells. While they have accomplished some good in this connection, during the past year the tendency has been towards their use in retarding flow from high-pressure wells rather than in prolonging flow in weak wells, and towards their use in larger sizes for a wide variety of purposes. Still further applications will undoubtedly be found during the coming year.



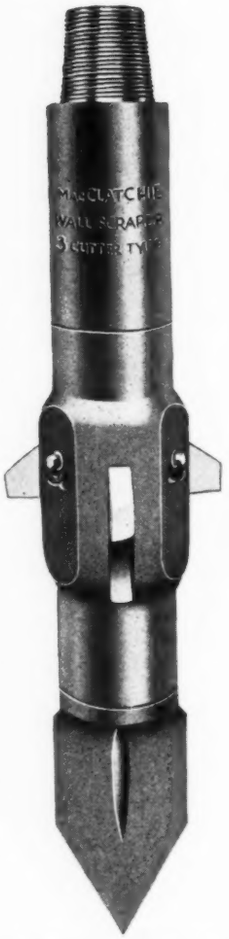
Method of preventing "freezing" at gas wells

How many legs to a MILK STOOL?

A milk stool may have any number of legs, but three are needed for stability. The same principle holds true for a wall scraper. Three cutters in the hole prevent gyrating and eliminate vibration and whipping of the drill stem. The remarkable performance of the MacClatchie Wall Scraper is due to its three cutters which insure a true circular bore. This three cutter assembly makes a stronger body which stands the gaff.

MacClatchie Wall Scrapers have been used on hundreds of wells without a single twist off. This tool is gaining popularity with operators everywhere. It pays to scrape the walls of a well and it pays to use a MacClatchie Wall Scraper.

A comparative run will convince you!



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  Correct distribution of cement can be obtained by scraping and enlarging the hole.

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  Recommended for scraping away the old cement when water has broken through before cementing again.

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  Enlarging the productive area with this tool increases the production on old wells.

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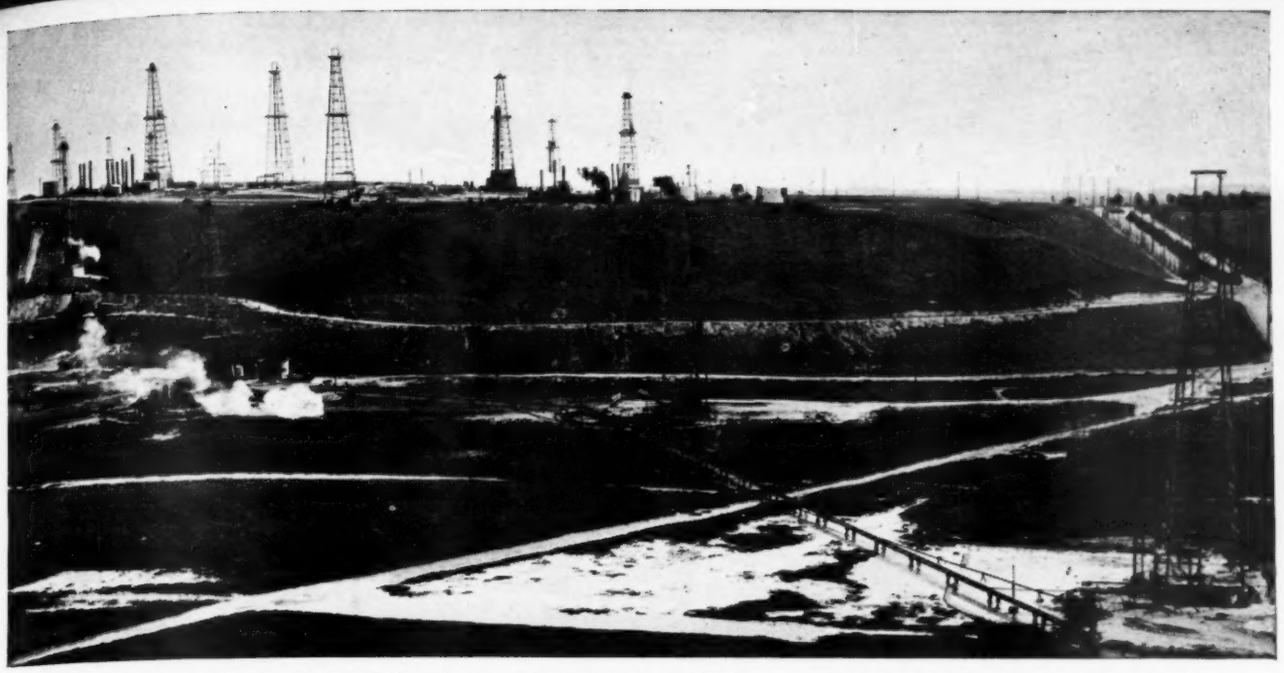

Looking from the direction of the old town lot area toward the new extension of the Playa Del Rey field
(Courtesy Union Oil Company)

California Operations Show Advancement in Technical Application

By WALLACE A. SAWDON
Petroleum Engineer, Los Angeles

IN reviewing drilling and production activities in California during the past year, our first thoughts naturally turn to a consideration of the trend of the industry. This is probably more important at the present time than it was a year or two ago, since the general indication of improvement in all industries should be reflected in drilling activity. That this trend is upward is encouraging; and that the upward movement is gradual is probably even more encouraging. If increased drilling and well completions can show a consistent but moderate increase, there should be a greater stability in future operations than there has been in the past.

It can only be hoped, however, that uncontrolled development will not attend the bringing in of any new fields; for there will probably be new fields discovered in California within a reasonable length of time. Wildcatting has not been popular during the last few years; and lack of potential production has not been exactly a cause of alarm. But times are changing and stocks are decreasing; and while the developed potential for California is estimated at nearly a million bbl. of oil per day, the state's quota is about half that potential. Moreover, potentials sometimes fall short of expectations; and do not always stand up under production as well as they might.

The increase in the number of active drilling wells and the producers completed during the year are graphically indicated in Fig. 1, which shows that both curves have reached a point higher than the average per month for the year 1931. Moreover, the number of wells now actively producing in California is almost 12,000, which compares with averages of less than 9000 during 1931 and 1932, just more than 9000 for 1933, and about 11,000 for 1934.

Considering the daily production from California, it will be noted that the actual production at the present time is being held very close to the allowable, with the average for the past couple of months falling a little below the quota. During April, of course, the tanker strike influenced the production to some extent. Of considerable interest, however, is the new method of allocation that has recently been inaugurated for Kettleman Hills.

This new method involves the application of an allocation formula and correlates productivity with bottom-hole pressure. Being recommended by the Petroleum Administration Board, its use was ordered by the Secretary of the Interior effective April 1, 1935. There were, however, too little data available to start work by that date yet preparations were so expedited that actual field work was commenced by April 22.

The object of the new method is to provide a more equitable distribution of allowable production. It is felt that those wells which have drawn more oil than they should, will indicate the fact by their bottom-hole pressure. The formula, which considers bottom-hole pressure as well as productivity, thus aims to establish well quotas that will tend to rectify unequal production.

The pressure tests will be taken every 60 days by the technical staff of the State Umpire's office. Up to date the only bombs available for use are the Standard and Amerada bombs; and with these, pressure readings will be made from top to bottom of each well. The first reading will be taken at approximately 1500 ft. and from there on at regular intervals until the productive zone is reached. Pressures there will be taken at the top of the perforations, in the middle of the zone, and at the bottom of the well. In certain circumstances where desirable, more pressures will be taken through the producing zone. The data will include shut-in pressure and three flowing rates.

While the present work involves only Kettleman Hills, it is being considered for Playa Del Rey and North Belridge.

Drilling

The deep drilling necessary in some of the California fields has probably put California in the limelight for its record depths. Completed just about a year ago, the General Petroleum well Berry No. 1 in the South Belridge field made the record for deep drilling at 11,377 feet. The real importance of this well, however, was its demonstration of our present facilities for drilling to 10,000 ft. and below.

With few exceptions, only modern rotary equipment of standard design was used in drilling this well. Yet there was a minimum of serious trouble encountered in the operation; and this fact has emphasized the value of applying the most advanced drilling technique. As far as deep drilling in this state is concerned, past experience has shown that greatest economy and the successful reaching of great depths under any conditions have been obtained by: (1) use of proper equipment, which has been made available by soundly developed designs perfected by the manufacturers; (2) application of experience gained in previous operations, which includes careful planning of the operation; (3) full coöperation between the technical staff, the management, and the field personnel; and (4), the utilization of all instruments and devices that aid in making drilling control as nearly complete as possible.

For some reason, it was felt by some that good rotary cores could not be taken below 10,000 feet. In the Berry well, however, core recovery averaged 85 per cent at depths below 10,000 ft., and practically 100 per cent recovery was obtained in the last 8-ft. core taken from 11,314 ft. to 11,322 feet. Coring with proper designs of rotary core barrels has been shown to be relatively as easy as straight drilling at any depth yet penetrated.

At the present time the deepest well being drilled in California is in the North Dome at Kettleman Hills. This well is K.N.D.A. No. 56-8Q and is an exploratory hole on the eastern flank of the dome. It was first drilled to 10,154 ft., and then had to be straightened from the 9200 ft. depth. It is now down to 10,213 ft. in new hole (May 15, 1935) and will possibly go another 600 feet. The hole is 8½ in. in diameter and is being drilled through 9-in. casing cemented at 8304 feet. The objective zone is the Krayenhagen.

A general summary of deep drilling methods and the equipment being used has appeared in a recent issue of *The Petroleum Engineer*.[1]

Directional and Straight-Hole Drilling

The past year has seen a remarkable increase in the use of surveying instruments during the actual drilling of a well. While the advantages of keeping a hole as nearly vertical as possible and reaching the objective in the shortest possible distance have been recognized for years, there has been a greater realization that corrections for deviation are more economical when made as soon as possible after the hole starts deviating. Instruments for measuring both the inclination and direction of a hole have been so simplified in operation that some of the companies use them after each and every run of the bit.

The entire course of the well is, of course, available for plotting when periodic survey readings of both the angle and the bearing are taken. The additional advantage of knowing just where the hole is with reference to surface location is thus provided. The elimination of errors in correlations and the knowledge of just where the well is located on the sand aid greatly in the development of a field.

The accuracy of surveys made during drilling is illustrated in Fig. 2. This well was surveyed with a magnetic instrument at fairly regular intervals from a depth of 2275 ft. to its bottom at 5554 feet. After completion an oriented survey was run from the "grass roots" down. The horizontal distance between the location of the bottom as shown by the magnetic survey and that as shown by the oriented survey is extremely small. Had the magnetic survey been started sooner, the difference would probably have been less. Of considerable interest, however, is the fact that the entire course of the well as plotted from records taken while drilling is so close to that determined by the oriented survey, which was continuous from top to bottom and taken after the well was completed.

Of particular importance during the past year has been the interest taken in directional drilling. The situation at Huntington Beach is well known although it still seems remarkable that so many wells drilled from such a variety of places on dry land could end up within such a small area in the productive zone beneath the ocean. The control of direction during drilling, however, opens up possibilities of a legitimate nature and there are many cases where it can be used with economic results. Moreover, it must be remembered that directional drilling will provide the necessary means of bringing a wandering well back to its own lease before reaching the sand after it has been allowed to deviate too far.

It matters little about the exact surface location of the well if it penetrates the producing zone at the proper place. The use of one location for more than one well to aid in the economic development of tidewater leases has been discussed. There are other surface conditions, however, that may make it desirable to locate the derrick at a distance from the point where the hole should reach the sand. The terrain may influence such location; or boundary lines may make unusual locations necessary. As an example of the latter, Fig. 3 shows how a hole may be directed to reach a

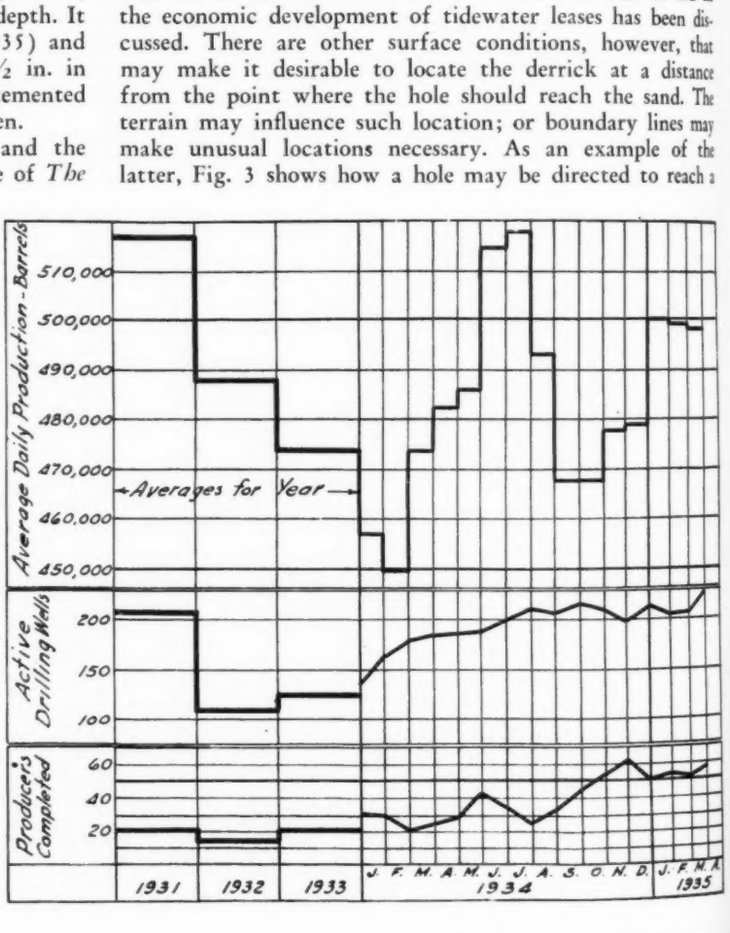

Fig. 1. Trend of the industry in California is here indicated. Data from A.P.I. as of April 1, 1935

[1] "Deep-Well Drilling in California . . . Methods and Equipment in use," *The Petroleum Engineer*, September, 1934.

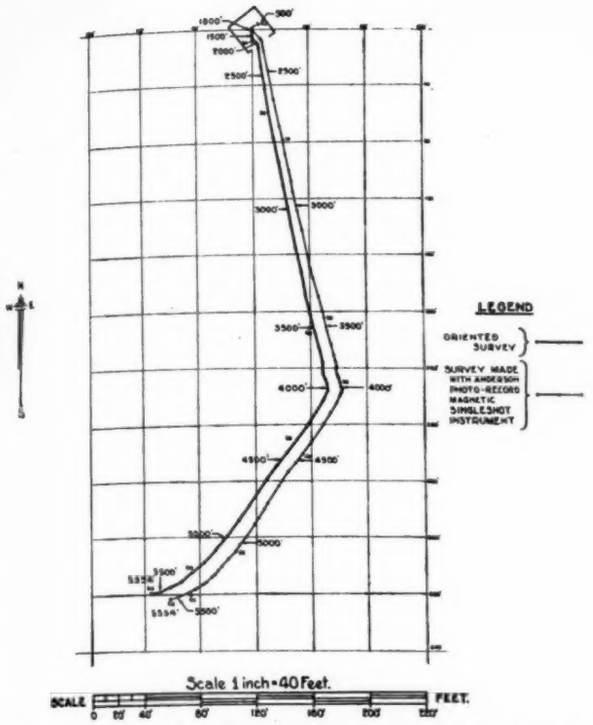

Fig. 2. A comparison between an Anderson Oriented Survey and a Magnetic Survey made with an Anderson Photo-record Magnetic Survey instrument

point within the lease when confined by irregular boundary lines.

Legislation covering the directional control of wells is pending in the California legislature. It is felt that bills now submitted will result in making mandatory the filing of surveys with the State Mining Bureau. One bill that is receiving support stipulates that a well must be completed within the lease boundary; and that the maximum average deviation shall not exceed three degrees. This would mean that a well could wander all over the field as long as it entered and stayed in the productive zone within the limits established.

Another bill, which is intended to be passed in addition to other regulatory measures, establishes the date of passage as the time when all regulations start. This does not preclude, however, prosecution against intentional illegal deviation when same can be shown or when suits have already been instigated. It aims to eliminate unjust action and the possibility of blackmail where old wells have been drilled beyond lease boundaries without intentional deviation. Cases have already been settled and damages awarded where intent has been proved; and there is every possibility that other cases of a similar nature will arise.

In spite of any drawbacks to any bills that are now being considered, it is practically assured that regulatory measures will be enacted. With the survey service, which has already been established by acceptance by the courts, and with the instruments now available for making survey readings during drilling, reliable plats of the course that a well takes underground can readily be furnished to the State Mining Bureau or other designated authority.

Deflecting devices used for directional control (which includes sidetracking or any passage of obstacles) have been, in the main, whipstocks and knuckle joints. The popularity of the knuckle joint has increased to quite an extent within the last three or four months, although whipstocking is still preferred by many operators. The character of the job has, of course, been the most influential factor in selecting the device used while some drillers rely mainly on drilling control not only in keeping the hole straight but also in bringing it back when it starts to deviate. In any event, there seems to be an extremely healthy inclination to complete wells as nearly below the center of the derrick as possible.

Speed of Drilling

The speed with which wells can be completed is naturally an economic factor. That fast drilling can be accomplished without sacrifice of other valuable considerations has been

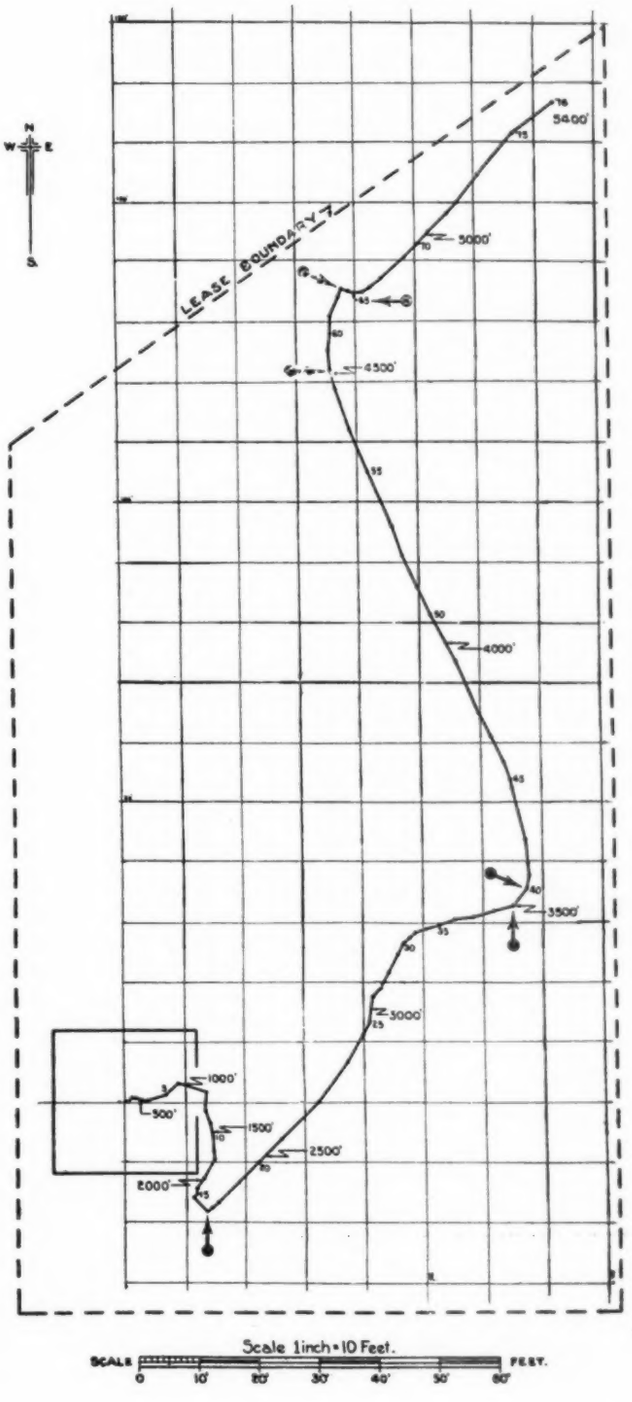

Fig. 3. Plan of rotary hole deflected for the purpose of completing well within north end of property. Places deflecting tools were used indicated by arrows
(Courtesy Alexander Anderson, Inc.)

Pier wells at Elwood. Directional drilling eliminates expensive pier construction when more than one hole is drilled from one location

demonstrated by the completion of three wells in the recent southeast extension of Playa Del Rey field. These were Union Oil Company's wells, Vidor 6, 7, and 8, which were completed to depths of 6152, 6217, and 6156 ft., respectively, in a total elapsed time of 109 days for all three wells. In addition, the crew drilled and set surface casing in two other wells while waiting for cement to set in the third well.

In all three wells, a 17-in. hole was drilled to about 750 ft., and 11¾-in. casing there set and cemented. Then 10⅝-in. holes were carried to about 6000 ft., where 6⅝-in. water strings were cemented. Below that and to the bottom, the holes were drilled with 5⅝-in. bits. Perforated 4¾-in. liners were run in and 2½-in. tubing installed for production.

In all the wells, cores were taken at the lower depths and the holes below the water strings were enlarged to diameters of from 7½ in. to 8¼ in. with a wall scraper; also, an electrical coring survey was made of each well, time for which was included in the elapsed time. In the 102 2/3 days that the crew worked, an average of 195 ft. per day was made, including the time utilized in running and cementing casing, coring, reaming, scraping, and all other incidental work.

A graphical representation of the work is shown in Fig. 4, which indicates the well-organized working plan that made possible the speed and efficiency of the operation. Surveys made of the wells showed them to have been kept very close to vertical with well No. 8, for example, never having passed beyond the limits of the derrick floor. Production obtained ranged in amount from 1600 to 8400 bbl. per day.

Cementing

Since the highest percentage of success in cementing jobs is the aim of all cementing companies, these organizations have naturally aimed to improve the methods and equipment used in mixing and pumping the cement into place. During the past year it has become an almost universal practice to use a time-pressure recording instrument on all jobs done in California. By means of this instrument a record is secured of the time taken up in mixing, the time utilized in pumping the cement, the pressure at any time during the operation, and the time and duration of shut-downs due to any accidents that might occur.

Such records, being automatic, give a check on the operation and eliminate causes of misunderstanding. Of further value, however, is the part they become of the well's history, since they furnish data that may be of considerable assistance in future repair work.

Some of the larger companies are using gel-cementing both for overcoming heaving shale and lost circulation and for cementing casing. This cement, made by adding a small percentage of a specially-prepared bentonite to Portland or special oil-well cement, is of greater consistency than neat cement and provides an angle of repose as high as 45 degrees. Its tendency to remain in place where deposited is naturally advantageous in shutting off crevices and fissures since it will not readily flow away as readily as a more liquid cement.

In cementing casing with gel-cement, there has appeared to be an advantage in both economy and effectiveness. When the colloidal material is mixed with the cement, a smaller quantity of the cement itself has been found necessary to do the job. In addition, however, the gel-cement is claimed to be able to eliminate contamination by the mud since it serves as a piston to force the mud ahead of it.

According to tests reported by W. T. Doherty,[2] there appears to be no effect on the setting time or tensile strength of cement when mixed in the proper proportions with bentonite. In fact, with water-cement ratios of 40 and 50 per cent, cement with four per cent bentonite shows a consistently higher tensile strength than neat cement in ages ranging from 1 to 365 days.

[2] "Oil Well Cementing in the Gulf Coast Area," by W. T. Doherty, A.P.I. Production Bulletin No. 212.

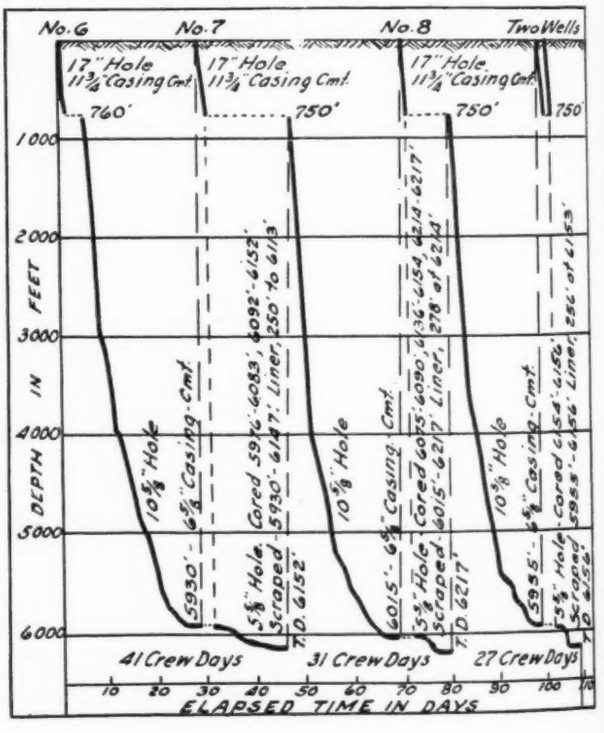

Fig. 4. In addition to the work as shown 2½-in. tubing was run in each well and the wells actually put on production in the elapsed time shown. Vidor lease, Union Oil Company, Playa Del Rey No. 8, completed March 27, 1935

Application of Scientific Methods

One of the outstanding increases in the adaptation of scientific instruments during the past year has been the use of electrical coring to such an extent that it has rapidly approached the universal in application. This does not supersede mechanical coring, but it cuts down the amount necessary, or, to be more accurate, it provides data that should be (and too frequently are not) obtained by extensive use of the rotary core barrel.

A fairly accurate estimate of the porosity and saturation of a formation can be made by electrical coring; and from the electrical measurements can be determined the nature of the formation. Of greatest importance, however, is the means it offers of correlating geological formations in the various wells in the same field.

In actual drilling, the use of the tachometer for governing rotating speed has made for economy, since this speed can be correlated with the weight carried on the bit to obtain greatest efficiency in bit performance.

Of considerable interest are the varied methods that have been introduced at various places to provide for future well corrections. In Kettleman Hills, for example, some of the wells drilled where previous experience has shown that water intrusion may be expected at a certain depth and at a time earlier than in producing zones above and below have been completed with blank pipe so placed as to lie opposite such stratum. The plan is to cement behind the blank section of pipe when the water shows up in the intermediate stratum to an extent that makes its exclusion advisable.

Another completion method being tried out in Kettleman Hills provides for production from different zones inside and outside the tubing and the casing. The successive zones have different productivity with different pressure and different kinds of oil. The segregation of the oils and their flow into individual separators and tanks provides sufficient reason for the development of the method.

The gun perforator has also shown advancement in application during the year and has led to the use of another new method of completion in the Long Beach field. A well was drilled through to the lower sand, passing up upper production. This upper production was cemented off behind the last protective casing string with the intention of gun-perforating it through the cement when production from it was desirable. In this case, however, sufficient clean production through a slotted liner run into the lower sand did not materialize; so the hole was plugged back and production obtained from the upper sand by shooting holes through the cement and casing. There was a shale break between the two sands that provided a good seat for the plug and an effective shutting-off of water found in the lower zone.

The greatest amount of metal perforated by the gun perforator in California has been four concentric strings of casing at a depth of about 2000 feet. The strings were 7-in. in 9⅝-in. in 11⅝-in. in 13½-inch. Of perhaps greater importance, however, is the use of the device for perforating under pressure. The method used for running the gun into the well under pressure is shown in Fig. 5. Flowing wells with pressures up to 2000 lb. per sq. in. have been shot in California although it has been reported that the device has been used with greater pressures in other parts of the country.

While mud fluid is primarily a function of the drilling operation, its influence on the completion of wells with rotary tools must often be given serious consideration. In the low pressure area in the Weed Patch, at Edison and at Fruitvale, the wall scraper has been used to advantage in removing the mud plaster from the producing sand. The mudding of the walls of the sand is here necessary to keep the water from the drilling fluid from entering the sand; but the pressure is too low to aid in removing the mud encasement. Washing was not entirely satisfactory but by scraping the hole and even enlarging it beyond the diameter originally drilled, the difficulty has been overcome.

The study of mud and the use of admixtures to give colloidal properties and weight is being followed continuously; and one of the major companies in California has started a series of tests confined to a determination of the effect of all kinds of muds and admixtures in varying percentages on all types of formations. The object is to gain as complete data as possible on penetration, water exclusion, adherence, effective plaster thickness, and all other factors that enter into the sealing off of sands and the best means of removing the mud sheath to provide maximum production.

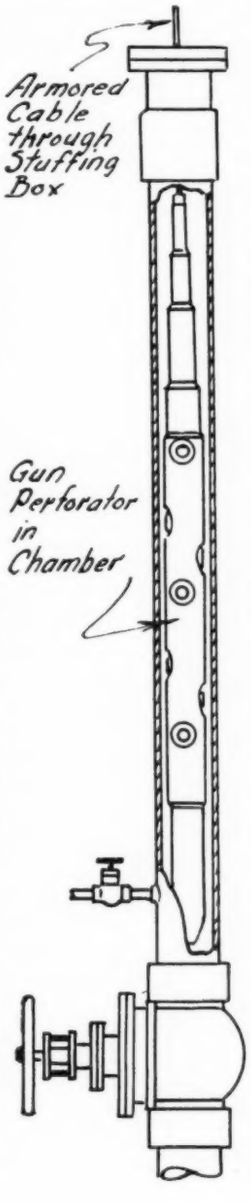

Fig. 5. Arrangement used for running in to perforate under pressure

Production

High-pressure production has reached a maximum in Continental Oil Company's well, Result 5, from the Wagon Wheel zone in the North Belridge field. This well showed a casing pressure of 3400 lb. and a tubing pressure of 2175 lb. when it was beaned back following the flow test to establish a potential. During the test, the production was at the rate of 8148 bbl. of 37 gravity clean oil with a pressure of 2250 lb. on the casing and 700 lb. on the tubing.

Fourl 1, which discovered the new Playa Del Rey extension November 16 last, was given a potential of 5000 bbl. per day. What will result from this field's development cannot be foretold at the present time.

New pumping equipment has been developed and several interesting designs have not only been tried out but have established themselves through efficient operation. There are at present, however, two or three types of pumping units that are being given field tests; but what results will be achieved cannot now be foretold.

In well repair work, the use of scientific instruments again shows the trend of technical advancement. Water location is being attempted with greater accuracy and new devices provide for close determination of the point of entry in both flowing and pumping wells. The use of special equipment for placing cement to exclude water is also gaining recognition and has led to a greater study of subsurface conditions in the application of technical methods for well maintenance.

Improved Arc-Welding Equipment Has Aided Pipe Line Construction Progress

By

C. M. TAYLOR

Vice-President, The Lincoln Electric Co.

• • •

THE use of arc welding in pipe line construction has experienced a remarkable increase in recent years. Over 10,000 miles of pipe has been welded by the electric arc since 1925, the first year arc welding was used in this work. Included in this total are lines from 4 in. to 28 in. in diameter and up to 1200 miles in length.

Such wide acceptance of electric arc in pipe line construction was due to very definite advantages of the process. Not only were speed and economy inherent with the process but the high quality of welds produced attracted widespread attention to its possibilities, especially after introduction of the shielded arc process.

Shielded Arc Process

Welds made by the shielded arc process showed remarkable physical properties. Tensile strength of weld metal rose from between 40,000 and 50,000 lb. per sq. in. to between 65,000 and 85,000 lb. per sq. inch. Ductility increased 15 to 20 per cent. Density became 7.82 to 7.86 whereas it had been only 7.5 to 7.7 grams per cc. Fatigue and impact resistance rose also, the former from 12,000-15,000 lb. per sq. in. to 28,000-30,000 lb. per sq. in. and the latter from 8-15 ft-lb. (Izod) to 50-80 ft-lb. (Izod). Corrosion resistance, poor in the case of welds made in an unshielded arc, became equal to mild steel.

The remarkable improvement in the physical properties of welds made by the shielded arc process were due to the protection provided the weld metal during deposition and cooling. This protection—a gaseous sheath around the weld metal during deposition and a layer of slag formed over it during cooling—prevented atmospheric oxidation of the weld metal.

Along with the improved results and lowered welding costs made possible by the shielded arc process, notable improvements have been made in gas-engine-driven arc-welding machines of the type used in pipe line work. The new welders furnished the higher voltage required for welding by the shielded arc process and are rated at 40 volts instead of 25 volts. These welders have 60 per cent greater kw. capacity and, due to their high efficiency, are more economical to operate than older machines of lower capacity.

Recent Developments Aid Welding

One of the most outstanding of recent developments in welding equipment, and one that has particular application in pipe line work, is a new remote control device that permits the operator to regulate welding current at the work without use of extra cables or rheostat. With this device[1] the operator can raise or lower current merely by tapping the electrode on the work. In addition to saving the time ordinarily wasted in walking back and forth between the welder and the work to adjust current, this device insures uniform quality of weld metal by eliminating the tendency on the part of the operator to retain original current settings. Advantages incident to the use of this device, called "Lincontrol," are readily apparent in pipe line work. Savings of hundreds of dollars per year per welder are reported possible.

[1]This device is available only on Lincoln welders.

Another piece of equipment of unusual value in pipe line work, and one that saves as high as 35 per cent on fuel consumption with gas-engine-driven welders, is an idling device that automatically slows down the engine 30 seconds after the arc is broken. The economies made possible by this device apply particularly in pipe line work. The time delay feature of this idling device allows the operator time to change electrodes without affecting welding current.

Steady improvement in arc-welding equipment has aided not only in the quality and speed of welding but has also permitted simplifying the procedure in pipe line work.

The type of joint used in the first application of arc welding in pipe line construction (1925) was the bell and spigot joint. In the early days only bare (unshielded arc) electrodes were available and joints had to be given added strength. Also prior to introduction of the shielded arc process, a welding dam was used on bell and spigot joints. With the advent of the shielded arc, pipe line companies were using the double bell joint with a backing-up ring or chill band. The purpose of the double bell was to preserve the inner diameter of the pipe and not offer any obstruction to the flow. The most recent welding

A recent pipe line welded with the latest shielded arc-welding equipment. The modern arc-welding machine is as far ahead of the old type (see other illustration accompanying this article) in efficiency as in appearance

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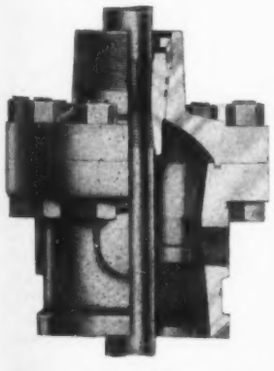

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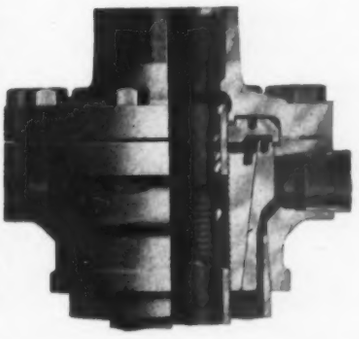

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practice in pipe line work employs straight-end pipe with plain butt joints.

One of the first instances of a pipe line constructed of straight-end pipe with plain butt joints was the 210-mile 8-in. Phillips Petroleum line from Oklahoma City to Thrall, Kansas. The average welding speed on this line was 56 roll welds per day; the record speed 86 roll welds per day. This unusual speed of welding—an average of nearly three miles per day—and the resultant economies were attributed to the use of the new type of joint, which greatly simplifies procedure. Since that time, the straight-end joint without chill band has been used extensively on many projects.

Standard Pipe Line Procedure

The standard procedure evolved for modern pipe line welding with the shielded arc is as follows:

Pipe is lined up in sections with the tacking crew following closely behind the line-up gang. When plain butt joints without backing-up ring are used, the pipe is lined up with a clamp and tacked.

The next section of pipe is fitted and tacked in three places. Tack welds about 1½ in. are made with ¼-in. shielded arc electrodes.

The usual firing-line gang consists of three to nine units depending upon the size of pipe. Each unit contains a welding operator, two helpers, and equipment. One helper turns the pipe, while the other stands by to clean the bead.

A special 18-in. length electrode has been developed for pipe line welding. The pipe used has either a 30-deg. or 45-deg. bevel.

After the first bead is run, the operator moves to the next joint. The helper cleans the bead while the pipe is turned. It is customary to complete the first bead in each joint of a section before starting the finish bead.

The number of lengths of pipe to a section is determined by the terrain. An effort is always made to use as many roll welds as possible to avoid bell-hole welding, which requires overhead operation of the electrode.

Following the firing-line gang come the bell-hole units. In many cases, two welders and one helper are used to permit greater bell-hole welding speed.

Inspection of welds follows. This usually consists of visual inspection although in many cases tests are made by application of air pressure to each completed section. Tests for tensile strength and ductility are usually made on coupons cut from the joints. Tensile strength tests made on 3000 miles of lines done with Lincoln equipment revealed an average tensile strength of close to 75,000 lb. per sq. inch. Ductility tests made by bending coupons cut from arc-welded joints revealed an average of 78 deg. bend in and 96 deg. bend out on one line while on another there were 97 deg. and 129 deg. respectively.

High Welding Speeds with the Shielded Arc

The steady improvement in arc-welding technique and equipment was reflected in the increased speeds with which pipe joints were welded. In the early days it was not unusual for a welding operator to spend as high as 90 minutes in welding a joint on 12-in. pipe. On the 1180-mile Iraq line, also constructed of 12-in. pipe, a record of 73 joints per man per 9-hour day was made. The following table shows a conservative average of pipe line welding speeds possible with the latest shielded arc welding equipment.

Dia. Pipe in Inches	No. Welds per Man Per 9-Hour Day
4	65
8	46
12	34
16	25
20	19
24	13
28	10

That these speeds are conservative is indicated by the fact that they have been bettered on many pipe line projects. For instance, a recent 26-in. line was welded at the rate of 21 joints per day, a 20-in. line at 35 joints per day; a 10-in. line at 60 joints per day.

Electric Arc as a Maintenance Tool

The speed and flexibility of the electric arc make it an economical maintenance tool for pipe line work. The quickness with which permanent repairs are made has reduced costs 50 to 90 per cent.

The shielded arc is regularly used in welding patches over fitted areas of pipe. In some instances, where corrosion has damaged a large section of pipe, arc-welding is used completely to encase the pipe. Leaky couplings, split sleeves, and joints are also quickly and permanently repaired by arc welding. One refinery recently saved thousands of dollars by entirely re-sleeving a sour crude oil manifold without any interruption in operations. What is by far the largest pipe line reconditioning job yet undertaken was recently begun in Texas. This line, which involves approximately 1000 miles of pipe, is being reconditioned entirely by shielded arc welding.

Advantageous to pipe line contractors, shielded arc welding also provides definite benefits to companies that own and operate pipe lines. The high welding speeds available with the process insure maximum economy in laying the pipe. The high quality welds produced insure permanently leakproof joints, good for the life of the pipe and consequently free from maintenance troubles.

In the early days of arc welding in pipe line work, the welding machine, even though a crude forerunner of the modern welder, called widespread attention to the possibilities of arc welding

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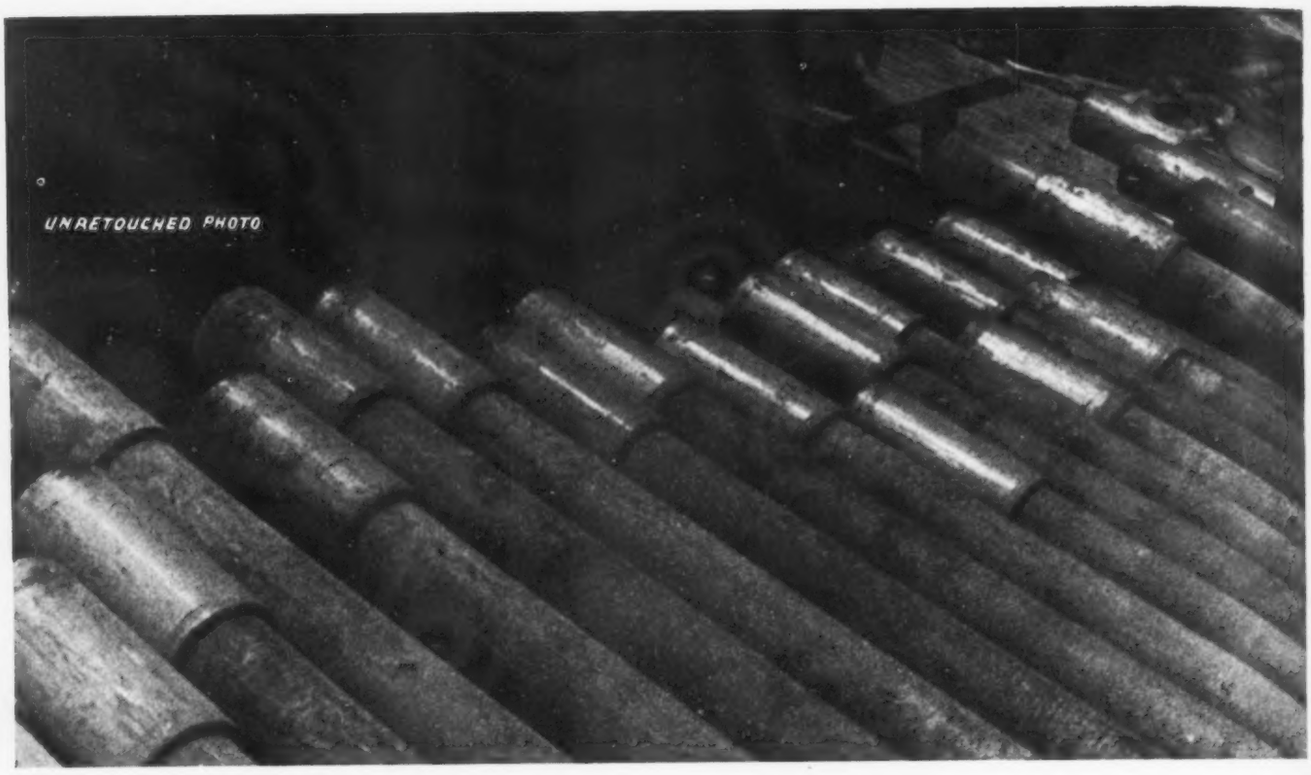

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Advances in the Utilization of Waste Natural Gas

New Profitable Uses for Gas Carbon Suggested

By MICHAEL J. LEAHY

THE problem of utilizing some of the vast amounts of natural gas at present being wasted has become acute. Proposals have been made that such gas be used for the production of various compounds or chemicals by means of one or more of the following methods:

(a) The production of larger proportions of carbon black by partial combustion methods.

(b) The partial oxidation of natural gas for the production of alcohols, aldehydes or organic acids.

(c) The pyrolysis or cracking of the gas for the production of unsaturated hydrocarbons such as acetylene, proplyene, etc., or aromatic compounds such as benzene.

(d) The complete pyrolysis of the gas for the production of hydrogen and carbon.

The principal economic objection to the use of any one of these proposals is that carbon in some form is produced simultaneously with any of the desired compounds. Such carbon may be in the form of carbon black, and therefore supposedly valuable as such; however, there are enough carbon black plants already in operation in this country to produce more than four times the amount of such material as can be marketed at present. Any increase, therefore, in the production of carbon without the development of new uses for such product merely aids in pauperizing concerns already engaged in carbon black production. Finely-divided carbon produced as a by-product in some of the above-named processes may not be used or sold as carbon black for various reasons; neither can it be used as fuel until it is mixed with a suitable binder and then pressed into briquettes. Further, natural gas that contains any appreciable amount of hydrogen sulphide may not be used in any of the above processes unless such impurity is first removed.

Accepting the hypothesis that if a means could be found for making use of the finely-divided carbon produced in the chemical processing of natural gas then one or more of these processes could be operated profitably, the author began a study of those compounds that would likely require considerable proportions of carbon for their manufacture. One of such compounds studied was carbon tetrachloride; but it was soon found that the only practical method of making this compound on a commercial scale was by the reaction of chlorine on carbon bisulphide. This led to a study of the latter compound. It was finally decided that the manufacture of carbon bisulphide itself offered the greatest opportunity for the commercial utilization of carbon.

With this in mind, a study was then made of the existing processes for making carbon bisulphide (CS_2), the patent situation on such processes, the possible uses and markets for liquid carbon bisulphide, and finally, the development of new processes and equipment for the manufacture of carbon bisulphide from finely-divided carbon and various forms of sulphur.

Commercial Methods of Making CS_2. The oldest known method of making carbon bisulphide comprises charging a retort with alternate layers of lump brimstone and lump wood charcoal. The retort is then externally heated to a high temperature; resulting in the formation of a pool of liquid sulphur in the bottom of the retort. As the temperature continues to rise, such liquid sulphur is vaporized and these vapors pass upward through the lump charcoal thus forming gaseous carbon bisulphide. These CS_2 vapors are passed to a condenser and there cooled. The liquid CS_2 is periodically drawn from the condenser.

While this method is simple and no complicated apparatus is required for its utilization, there are several serious drawbacks to its use. For instance, the retorts used deteriorate very rapidly due to the corrosive action of CS_2 at the exceedingly high temperatures required; if the sulphur used is impure or the wood charcoal contains much ash, then the slag formed in the retort is of such a nature that the task of removing it becomes very difficult; the sulphur and charcoal used must each be in the form of lumps in order that the vapors may readily pass upward through the mass in the retort; and finally, since wood charcoal normally contains some hydrocarbons and also adsorbs air, the CS_2 formed by this method is contaminated with hydrogen sulphide and organic sulphur compounds, and necessitates the use of complicated rectification apparatus for the production of pure CS_2.

An improvement over the method just discussed comprises vaporizing the sulphur in a separate container, superheating these vapors, and then injecting them into a retort packed with lump charcoal. The retort, of course, must be externally heated also. The charcoal used may be previously calcined in the presence of an inert gas in order to drive out the adsorbed air and to distill out, or decompose, any hydrocarbons present. The CS_2 produced by this method is relatively free of hydrogen sulphide; but considerable free sulphur is dissolved therein due to condensation of sulphur vapors as well as carbon bisulphide in the condenser. Repeated rectification must therefore be employed; also, the wood charcoal used must be in lump form. The temperatures prevailing in the interior of the retort, however, are lower than those needed in the first-named process.

Another method of producing carbon bisulphide—and one that has been highly developed in this country — comprises charging the proper proportions of lump charcoal and lump sulphur into a vertical retort near the base of which are positioned a number of carbon electrodes. An electric current is passed through these electrodes, thereby heating them. Sulphur coming in contact with these heated electrodes is melted and then vaporized. These vapors on their passage upward through the retort melt further quantities of sulphur; thus forming a pool of molten sulphur around the electrodes. Lumps of charcoal that fall into this pool form conductors for the electric current and so relieve the strain on the electrodes. Naturally, these heated lumps of charcoal are con-

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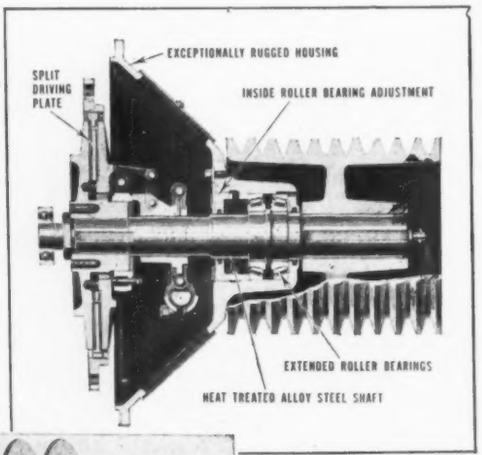

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tinuously decomposed to form CS_2 vapors. These vapors are then separately condensed and rectified. Again in this process lump materials must be used, the carbon bisulphide produced is impure, any slag formed in the retort increases the consumption of electricity, and finally, the cost of electric power itself is a serious item.

There are a large number of variations of the above methods and numerous combinations of two or more of these methods in use or which have been proposed. In all cases, however, lump charcoal is specified.

Patent Situation Respecting the Production of CS_2. The author has made an exhaustive study of the patents that have been granted on processes for making carbon bisulphide. A patent search was made back through the records to the year 1873. A bibliography of the U. S. and foreign patents found that seem to be pertinent to the subject and of some recent literature dealing with the uses of carbon bisulphide is appended. Since this study was made primarily to determine the technical phases of the situation and not to attempt to evaluate such patents from a legal standpoint, no references to specific patents are made in the body of this article. Anyone interested in the legal phase may obtain copies of desired patents from the proper authorities.

Present Uses and Markets for Liquid Carbon Bisulphide. Carbon bisulphide is used in the making of viscose rayon, carbon tetrachloride, paint removers, matches, and germicides; as a solvent for oils and fats, sulphur, phosphorus, iodine, camphor, wax, tar, resins, rubber, etc.; as an insecticide in agriculture; for the extermination of weevils in grain, moles, rats, prairie dogs, woodchucks, and other burrowing animals; in the manufacture of rubber cement; and in refrigerating machines.

It is extremely difficult to estimate the amount of carbon bisulphide produced annually in the United States due to the fact that practically all manufacturers of viscose rayon produce their own carbon bisulphide and hence no public record is made of the amounts so produced. In 1931, however, the recorded production in the United States was in excess of 83,045,219 lb. and approximately 3,000,000 lb. was produced for export during the same period. It may be mentioned in passing that much more carbon bisulphide would be used for sterilizing soils and for extracting oils from various seeds if it could be produced and sold more cheaply.

Development of New Processes for Making Carbon Bisulphide. Starting with the assumption that, as a rule, finely-divided materials will unite chemically and at lower temperatures far more readily than will lump materials, processes and apparatus have been developed and perfected for the production of carbon bisulphide that, in the main, comprise mixing finely-divided carbon with finely-divided sulphur and then heating such mixture in a closed retort—either in the presence or absence of catalysts—to produce CS_2 vapors, which are then condensed. The forms of finely-divided carbon that may be used in these processes include: Ground coke, coke screenings, *petroleum coke, carbon black,* lampblack, decolorizing carbon, finely-divided charcoal, amorphous carbon, etc.

Finely-divided sulphurs that may be used in these processes include: Mechanically-ground sulphur, sulphur screenings, flowers of sulphur, precipitated sulphur, heavy sulphur dissolved in carbon bisulphide liquid, colloidal sulphur, etc.

One method of using these processes consists in mixing finely-divided carbon obtained from the incomplete combustion, partial oxidation, or pyrolysis of natural gas with brimstone sulphur dissolved in carbon bisulphide liquid together with varying amounts of sulphur screenings or precipitated sulphur and then heating this pasty mixture in a retort to form CS_2. Any residual liquor remaining from the con-

densation, or rectification, of the carbon bisulphide vapors formed may be returned to the process for use in dissolving further quantities of heavy sulphur.

While experimenting with various modifications of these processes it was found that finely-divided carbon mixed with the sulphur precipitated from solutions used for removing hydrogen sulphide from "sour" natural gas would produce carbon bisulphide of relatively high degree of purity at much lower retort temperatures than must ordinarily be employed. Such temperatures could be further reduced by the addition of suitable catalysts to the mixture. This means, therefore, that it is now economically feasible to treat the "sour" gases at present being wasted in the Permian Basin—and which contain up to 14 per cent hydrogen sulphide—and produce finely-divided sulphur therefrom. These gases will thus be made fit for use as a fuel and the sulphur obtained may be profitably employed in the production of carbon bisulphide.

It was also found that petroleum-still coke could be used profitably in these processes. Thus refiners operating on high-sulphur crudes may now treat their fixed gases for removal of hydrogen sulphide therefrom—such gases contain up to 48 per cent H_2S—and precipitate sulphur from the treating solutions. Such sulphur may then be mixed with the coke from their cracking stills for the production of carbon bisulphide.

Many other modifications of these processes will be apparent to anyone making a close study of them. However, it is the author's belief that the immediate field for their utilization lies in the natural gas industry. By means of these, the necessarily large amounts of carbon obtained as a by-product in the various methods of chemical conversion of natural gas may be used profitably and thus make such conversions themselves feasible.

Since one lb. of carbon unites with 5.33 lb. of sulphur to produce 6.33 lb. of CS_2, if it is assumed that but one lb. of finely-divided carbon is obtained from the processing of M cu. ft. of natural gas, then 6.33 lb. of carbon bisulphide may be made per M cu. ft. of gas. Commercial grade liquid carbon bisulphide sells for about 5½ cents a lb., wholesale, in car lots at the point of production. A gross revenue of about 35 cents per M cu. ft. of gas processed may be obtained from the sale of CS_2 alone; or this carbon would have a value of 6½ cents a pound.

A number of investigators assert that they have produced up to 4.4 lb. of carbon and 3.4 gal. of benzene per M cu. ft. of natural gas by thermal decomposition in the presence of an excess of carbon. Since benzene sells at 21 cents a gal. and about 28 lb. of CS_2 may be produced from 4.4 lb of carbon, it follows then that the total gross revenue would be $2.25 per M cu. ft. of gas processed. It is very likely, however, that the true value of the gas for the production of chemical compounds lies somewhere between the above extremes.

In conclusion it may be well to state that the described processes for making carbon bisulphide from finely-divided carbon and sulphur and the apparatus therefor are protected by a number of pending patents and applications for patents. Therefore these processes may not be used—except under license—without the possibility of facing suits for infringement.

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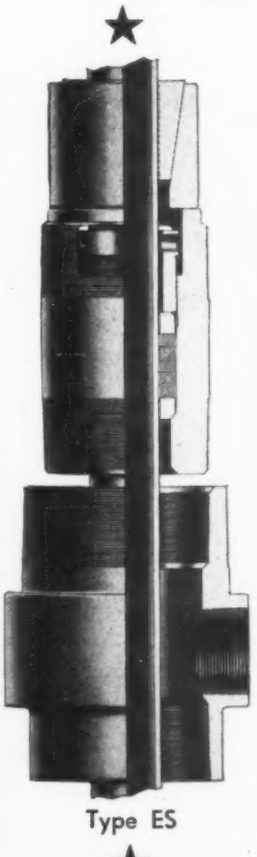
(Continued on page 98)



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A Petition to the CONGRESS

Submitted by the
AMERICAN PETROLEUM INSTITUTE

The AMERICAN PETROLEUM INSTITUTE, with a substantial and representative membership from a $12,000,000,000 industry, which has more than 2,000,000 owners and over 1,000,000 employes, respectfully petitions Congress to pursue policies which will permit this industry to take its rightful place in the march of recovery.

The Institute asks this with full appreciation of the earnest endeavors which have been made by the federal authorities, in the past two years, to speed recovery. These efforts the petroleum industry has generously supported, recognizing that in a time of such emergency it had a patriotic obligation to co-operate in bringing about re-employment and restoring the country's purchasing power. Its annual payroll, approximating $1,569,600,000, is practically equal to the 1929 payroll, and in real wages it is 7.2 per cent higher. In fact the per capita yearly wage paid by most of the oil companies has always ranked high in industry. In the past two years the industry reabsorbed 217,200 persons. Taxes on its properties, products and operations contribute $1,250,000,000 annually toward the maintenance of government.

The Institute believes that the people who depend upon our 24,600,000 automobiles for transportation, the farmers who cultivate the land with tractor-drawn equipment, the operators of thousands of industrial plants and the many other users of petroleum products are best served when competition is free, when the operation of economic law is unhampered and when the profit incentive stimulates initiative and inspires invention. The free operation of these forces inevitably tends to insure quantity, improve quality and reduce prices. These are the true tests of the service rendered by any industry to the public.

GASOLINE consumers cannot continue to enjoy these advantages if the responsibility of management is transferred from the thousands of individual companies to a federal bureau. These advantages can be assured if the federal and state governments will remain each in its own sphere, observing the separation and limitation of powers which the Constitution has wisely ordained and the Supreme Court by many decisions and precedents has clearly defined.

Legislative uncertainties, threats of governmental control and interferences with the legitimate development of a great industry which has served the public satisfactorily are handicapping our business and retarding progress toward a constructive solution of our problem.

OUT OF an intimate knowledge of conditions and a long experience in serving the American people we feel qualified to offer a program of principles which will materially assist in stabilizing conditions under which the oil industry can operate to the direct advantage of both makers and users of petroleum products. We respectfully submit:

FIRST: That there should be a minimum of regulation by government, state or federal, to the end that private industry may be free to serve the public most efficiently and economically.

SECOND: That the state governments, having the power to regulate production of crude oil and natural gas to prevent waste and so conserve a valuable natural resource, should be encouraged in that effort.

THIRD: That the Federal Government, having the power to deal with interstate and foreign commerce, and to authorize interstate compacts, should supplement the production control effort of the states:

By making permanent and rigidly enforcing the Connally Law (S. 1190) prohibiting shipment in interstate and foreign commerce of oil produced in violation of state laws;

By approving the interstate compact which has already been ratified by the legislatures of five of the principal oil producing states;

By directing the U. S. Bureau of Mines, a competent fact-finding agency, to ascertain the crude oil production necessary to meet the consumptive demand of the nation and to make its findings available to the interstate compact commission and the respective conservation authorities of the oil producing states;

By exercising control of imports to a proper ratio to domestic production for such a time as is necessary.

FOURTH: That as concerns marketing, the field of greatest competition, there is no reason to single out the oil industry for special federal intervention. That industrial pacts and agreements when voluntarily made by any industry for the purpose of eliminating unfair methods of competition should be permitted.

FIFTH: That any such economic straitjacket as is contained in S. 2445 or similar proposals for the enlargement of the N. I. R. A. would serve to increase the price of gasoline and demoralize the industry.

IN SUPPORT of the foregoing we point to the record of the oil industry during the last fifteen years as one of outstanding public service.

But for cheap gasoline many industries which have contributed substantially to American economic progress could not have enjoyed such remarkable development. Notable among these are automobile and tire manufacture and modern road building, with the related industries such as steel, textiles, plate glass, leather and numerous accessories.

The production, transportation, refining and distribution of petroleum and its products go hand in hand with the automotive industry. Important as it is that automobiles should meet all reasonable demands upon them, it is equally important that the car owner, wherever he may travel, should have access to a plentiful supply of gasoline and oil, of good quality and at reasonable prices.

DURING the last fifteen years the efficiency of American-made automobiles has steadily increased, while their price has as steadily declined. Today, the United States makes 75 per cent of all the automobiles in the world. During the same period the petroleum industry has supplied the car owner with gasoline and oil in ample quantities, of constantly improved quality and at steadily decreasing prices.

OF THE UNITED STATES

In 1920 the average selling price of gasoline exclusive of tax in fifty cities, representing all the states, was 29.7 cents per gallon; in 1934 the figure for the same cities was 13.6 cents—a drop of 54.2 per cent. A barrel of crude petroleum now yields about twice as many gallons of gasoline as it did fifteen years ago. No consumer of gasoline and oil can reasonably complain that he cannot readily procure a plentiful supply of each, of good quality, at reasonable prices. The average cost exclusive of tax of owning and operating a motor car today, mile for mile, is about one-fourth of what it was fifteen years ago.

The free play of economic conditions under which these two great industries have so well served the consumer has been substantially the same. In both there has always been keen, unrelenting competition; and this, in turn, has stimulated new discoveries and new methods, has led to the development of new markets and has constantly tended to improve quality and reduce prices.

BECAUSE it has grown so fast, the oil industry has constantly needed large amounts of new capital. Its investment increased from $6,350,000,000 in 1921 to $12,200,000,000 in 1932. During these twelve years $2.94 of new capital was put into the industry for every dollar that was earned, and the annual average earning of the oil industry on its investment was only 1.66 per cent. It is inconceivable that political management could operate a fast-growing and hazardous business on so close a margin as this.

In transportation, particularly, which is such an important factor in costs, the oil industry has devised and developed its own unique systems, giving incomparably cheap movement by pipelines, ocean tankers, and by barges on inland waterways.

Every resource of science and technology has been enlisted in the search for new supplies of oil in the earth. In fact, the chief offense imputed to the industry is that it has been all too successful in finding new pools.

WITH such a record it is apparent that the hands of the oil industry should not be tied by governmental bureaucracy. The issue between government and private responsibility for this vast industry should not be obscured by vague declarations that the petroleum industry has become affected with a public interest justifying governmental control just because conservation has come to be recognized as a responsibility of government.

The distinguishing characteristic of petroleum and natural gas is their liquid and fugacious nature. In other mining industries the situation is entirely different; for instance, the owner of coal land is not subject to drainage, for he can keep his coal if he likes and his neighbor cannot take it. But when a well is drilled into an oil producing area the "law of capture" permits the surface owner to draw the oil from his well even though it may drain the supply of the adjoining land owner. Therefore, the neighbor must drill and produce his share of the oil or lose it; and his neighbor in turn must do likewise. This was a situation beyond the power of the industry to remedy, and in all flush pools, before the conservation efforts of the states were effective, the "law of capture" resulted in unscientific and wasteful practices and overproduction. The oil producing states and the industry itself have now come to an intelligent conception of what real conservation means. The industry believes that true conservation means the scientific control of production making for greater recovery, as well as efficient and economic utilization of crude oil.

IT IS the duty of the oil producing states, in the public interest as well as in the interest of the industry, to prevent waste of crude oil and thereby conserve the supply. This duty is the obligation of government, and when that obligation shall have been discharged there is nothing in the inherent nature of petroleum or in the conduct of the business which requires or justifies the oil industry being declared a public utility any more than in the case of any other producer or manufacturer of a commodity of general use.

In marketing gasoline, the problems are no different from those in the wholesaling and retailing of other commodities. Whether there are too many filling stations; whether there is waste in the number of retail stores that market clothing, groceries, beverages or the like, is a problem that concerns our economic welfare as a whole and not particularly any one business. It is self-evident that the problems arising out of competition and the operation of economic laws in every hamlet in the country cannot be solved by a bureau at Washington which undertakes to regulate each minute detail of our vast and complicated business structure. There should be no economic tinkering, and no political control.

UNFORTUNATELY, governmental agencies, once organized and endowed with some measure of authority, aspire to continue their existence and increase their authority. Any proposal to amend the National Industrial Recovery Act with provisions that convert it from what is theoretically a system of governmentally supervised, industrially self-regulated codes of fair practice into a system of federal industrial dictatorship becomes a striking example of this tendency to encroach.

We have proceeded on the road to recovery sufficiently to consider methods of orderly development of business as a substitute for devices created in moments of national emergency and desperation. The time has come to consider the long range view of American economic progress.

The oil industry is prepared to do its part, and demonstrate its confidence in itself and in the future of the country, if it can but know clearly that its efforts are not to be checkmated by constant change, bureaucratic dictation or usurpation of power.

Congress has an unparalleled opportunity to aid recovery by a frank recognition of separate fields of federal and state responsibility under the Constitution.

Respectfully submitted, by order of its Board of Directors,

AMERICAN PETROLEUM INSTITUTE

AXTELL J. BYLES, *President*

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A section of pipe upon which numerous patches have been welded

By

FRANK H. LOVE

Proposed Classification Plan For Used Line Pipe

WITH the reconditioning and reclaiming of pipe occupying a position of constantly increasing importance in the pipe line industry, a long-felt need has existed for a practical uniform system of classifying and grading used pipe as to its physical condition. The benefits of such a system are manifold. A vast opportunity is offered for economy in handling pipe. One operator has expressed himself on the subject in this manner: "It is quite apparent that second-hand pipe that has been brought into the storehouse is not handled in a systematic manner. The lack of a definite classification system results in excessive costs for repiling and resorting as the pipe is sold or used." It is apparent also that considerable used pipe suitable for pressure service can accumulate in stock in the absence of definite instructions on the classification and use of pipe.

In addition, a classification system offers opportunity for the accumulation of records on the condition of pipe. Such records are useful not only in affording estimates of the amount of recoverable pipe in dismantling lines, but also for identifying the corrosiveness of the various kinds of soils along the right-of-way. This latter information becomes of value when new lines are laid through the same or similar territory.

To meet the need here briefly outlined the American Petroleum Institute's topical committee on corrosion of pipe lines, after due consideration, unanimously adopted a tentative classification scheme for used line pipe during the mid-year meeting of the A.P.I. at Tulsa, a meeting well attended by engineers of the carriers in addition to the members of the corrosion committee.

The proposed classification scheme has been in process of formation for some time, being the result of a questionnaire sent to the industry, and represents, therefore, the present best practice. The work of gathering and assembling the data was handled for the corrosion committee by Dr. Gordon N. Scott, pipe line technologist for the A.P.I.

Pipe repaired by patching and spot welding

Badly pitted pipe

The classification scheme as proposed by the committee is shown on the next page.

The carriers are unanimously in agreement that for use no real discrimination should be made between new pipe and Grade A recovered and repaired pipe, as experience has demonstrated that this pipe is substantially as good as new.

Grade A repaired pipe includes all pipe repaired by spot-welding, patching or joining so that no pits in excess of one-fourth the wall thickness remain.

Several operators, by means of welding, restore badly corroded pipe to a condition acceptable for high-pressure service. For laid pipe this is evidently true of all operators who reclaim by welding. A marked tendency exists among operators to allocate the lower grades of corroded pipe to low-pressure service or to well-drained non-corrosive areas instead of the less satisfactory repair of used pipe by welding. The reclaiming of pipe from Classes B and C by welding procedure, in order to obtain stock that will then grade Class A, is not regarded as sound practice. Normally the pipe in Classes B and C can be used more economically in its existing condition.

Many operators, in repairing laid pipe, prefer not to repair by welding areas pitted to a depth of less than one-half the thickness of the wall. Adoption of this limitation permits the use of considerable quantities of pipe for non-corrosive areas and those of good drainage, in medium to low-pressure service.

Pipe pitted to an extent in excess of one-half the wall thickness of the pipe but where the pipe is not punctured shall be placed in Class C. Pipe of this classification, when the condition of the threads is such as to permit coupling without danger of leakage at the joints, may be used in temporary gravity lines or in service where pressures are extremely low.

If the affected areas are restricted to short lengths, and there exists not less than four ft. of pipe of Grade A characteristics, cutting out of such good sections and welding to usable lengths of Grade A-recovered pipe, is recommended when facilities are available. All discarded sections are classified as junk.

Junk pipe includes all perforated sections and short pieces from Class C that are unfit for use as pipe. This classification also should include all scrap, such as dutchmen, and pipe abandoned in the ground.

Often it is inexpedient or impractical to grade certain lengths of pipe, and in such cases the pipe may be allocated to a temporary Class X in which the pipe is unclassified. Such, for example, as pipe encased in rust scale that is difficult to remove. Pipe so rusted is often allowed to weather for an extended period to facilitate the removal of the scale.

Since the visual inspection of pipe is uncertain and unreliable, and in order to avoid this human element, the corrosion committee states that some quantitative basis for gauging the condition of a corroded pipe is necessary. The instrument available at present for measuring pits is the Moorlane gauge, devised by J. Campbell Stirling and C. M. Scott, Jr., of the Stanolind Pipe Line Company.

The corrosion committee of the A.P.I. contemplates preparing a complete manual on the classification of corroded pipe of which the adoption of the classification scheme here outlined constitutes the principal step.

Lack of information on internal corrosion prevents the writing of speci-

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As every production man knows, a good part of down time on pumping wells results from cut-out Seats and Balls. Frequently this cutting-out is the result of brittleness. Fine fissures develop which open up under pressure, after which the Seat is easily cut away.

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A tolerance of plus or minus one point of a required hardness is set for Flupaco Seats and Balls, and *each* seat is tested on a Rockwell Hardness Tester to insure its meeting this requirement.

Flupaco Seats and Balls are made in both the Ring Type and the Flat Type for all makes of pumps.

A report on the material used and process of manufacturing Flupaco Seats and Balls is available on request.

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fications on pipe thus affected. However, a requirement to the effect that the inside of the pipe must be commercially smooth and clean, will be included in the manual.

The practice of repairing pipe by welding at present is still in an experimental stage. Opinions differ as to the amount of welding required to repair adequately a corroded pipe.

Class	Description	Service	Soil condition
A—new	New pipe.	High pressure.	Any.
—recovered	Pitted less than ¼ the wall thickness.		
—repaired	Pipe of Class B repaired by spot welding to Class A—recovered condition. Pipe reclaimed from Class C or Junk by joining.		Any, except in known "hot spots."
B—recovered	Pitted greater than ¼ the wall thickness but less than ½ the wall thickness.	Medium to low pressure.	Non-corrosive Hilly country
—reclaimed	Pipe of Class C repaired by spot welding and/or patching.	Low pressure.	Well-drained areas.
C—repaired	Pitted greater than ½ the wall thickness but not penetrated.	Temporary gravity.	
Junk	Perforated, scraps from cut pipe, dutchmen, pipe abandoned in the ground.	Unfit for use as pipe.	
X	Unclassified.		

Interest has been expressed in the possibility of studying this subject in detail with the purpose of ultimately preparing a good-practice statement.

Interest also has been expressed in developing a uniform system of maintaining corrosion records. Such a system would be particularly desirable for companies that at present keep no records. There would be no intention of introducing innovations into the practice of those companies already maintaining complete records, but a manual on the subject would provide a guide for companies contemplating keeping such records, or new companies that have not yet had extensive experience with corrosion.

New Accounts to W. L. Walker Company

The W. L. Walker Company, 800 South Main Street, Tulsa, Oklahoma, has been appointed manufacturers and distributors for the Imperial Automatic Shut-off valve that is used by pipe lines for gravity and vacuum gathering systems, as well as on irrigation and coal mine drainage systems. They also have been appointed manufacturers and distributors for the Master Gage Oil Thief. Literature on this equipment can be obtained by writing the manufacturer.

L. W. Lyons Elected Westinghouse Treasurer

L. W. Lyons, widely known in the industrial world, was recently elected treasurer of the Westinghouse Electric & Manufacturing Company, succeeding Herman F. Baetz, who is retiring from active duty.

Joining Westinghouse in 1904, Lyons has continuously been a member of the credit department and for many years prior to his election as treasurer served as manager of this important department. He has also held the positions of assistant secretary and assistant treasurer. His career has been that of a specialist in credit problems and accounting procedure of a nature encountered in a large corporation doing business internationally.

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Research in Manufacture of Oilwell Pump Liners

YEARS of research have been spent in the metallurgical laboratory analyzing and testing all materials and operations employed in the manufacture of all types of oilwell pump liners. This research is responsible for the development of a series of pump liners designed to meet the demands of greater resistance to wear and corrosion.

For a great many years little thought was given to the properties of cast iron, other than its machining qualities. As more severe conditions were imposed upon cast-iron products, as was the case in oilwell pump liners, it became evident that something must be done to increase the strength and hardness, also to withstand the hydraulic pressure encountered in the operation of oilwell pumps. To obtain these qualities it was necessary to install complete chemical and physical testing laboratory equipment in order to maintain constant control of the materials and for correlating results of the many tests that were involved. The Axelson Manufacturing Company, for 35 years one of the foremost manufacturers of oilwell pump liners, has done much research work on their products and its manufacture. For example, tests are made on the following materials:

1. Liner Cores
   a. Grain of sand and mixture proportion
   b. Bond
   c. Oil
   d. Fusibility
   e. Compression strength
   f. Permeability
   g. Drying temperature
2. Molding Sand
   a. Grain size
   b. Fusibility
   c. Wet and dry compression strength
   d. Permeability
   e. Moisture content
3. Materials Used in Producing Liner Iron
   a. Pig iron
   b. Steel scrap
   c. Returned scrap
   d. Coke
   e. Limestone
   f. Flux
   g. Material for lining cupola
   h. Alloys added

In the process of research, these numerous factors were presented and it was learned that each one played a very important part in the resultant product. It was learned from the data compiled that by raising or lowering the silicon, carbon, and manganese, and by the addition of various proportions of alloys, a wide range of hardness, strength, and grain structure were available. At this time a great many microscopic examinations were necessary to ascertain the correct proportion of elements required to produce the best material for these specific products. It was found upon the addition of .50 to .75 per cent nickel, with .20 to .30 per cent chromium, the liner iron gave an extremely hard, tough, and strong product without impairing the machineability. Nickel and silicon are graphite-forming elements. Chromium

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is essentially a carbide former, reducing the graphitic carbon and decreasing the flake size of the graphite. Chromium, if used alone, has the tendency to promote chills. Thus, nickel was used with chromium in the proportion to which they mutually neutralize each other in respect to chill. The resultant alloy had the same tendency to chill as the iron to which the alloy was added. At the same time the refining, matrix hardening and strengthening effects of both elements were reflected in the finished liner.

The liners produced from this quality of iron had a Brinell Hardness of 196 to 207. At this time the problems of strength and resistance to withstand the hydraulic pressure incurred were materially improved, as well as the resistance to corrosion, and an increase in hardness. Still, liners of greater hardness and abrasion resistance were being demanded. It was learned that cast iron was directly comparable to steel in its reaction to heat-treatment, the fundamental differences being the presence of free graphite particles in cast iron.

Liners made from common soft gray iron had a coarse interlocking structure, due to the excessive amount of graphite and a ferritic matrix, and this structure was not capable of being materially improved by heat treatment. By maintaining close control of the cupola, and by the addition of larger percentages of steel scrap, it was possible to bring the graphitic carbon down, and to raise the combined carbon by the addition of alloys—the combined carbon being the primary factor for hardening by heat treatment.

A great deal of experimenting was done on the heat-treating of liners made from various alloys of cast iron resulting in the molybdenum cast-iron liner for both plain and heat-treated liners. While molybdenum is a great deal more expensive than nickel-chromium, the benefits derived are worth the additional expenditure. By the addition of molybdenum to the liner iron, both complex carbides and solid ferrite solution are formed. As a carbide former, molybdenum is less drastic in its action than chromium. It has a tendency to cause the flakes of graphite to become nodular in form with consequent improvement in physical properties. It is the most effective alloying element added to cast iron, and definitely increases the wear resistance.

Molybdenum retards the critical transformation in both the liquid and solid state, which makes the graphitizing slower. These effects help in the heat-treating processes, also the retention of strength and other properties at elevated temperatures. The addition of molybdenum also promotes structural uniformity, resulting in good density, high Brinell Hardness, and high strength maintained throughout the cross section of the liners.

Following are the typical analyses of iron produced for molybdenum cast-iron liners, stress relieved at 1000 deg. fahrenheit:

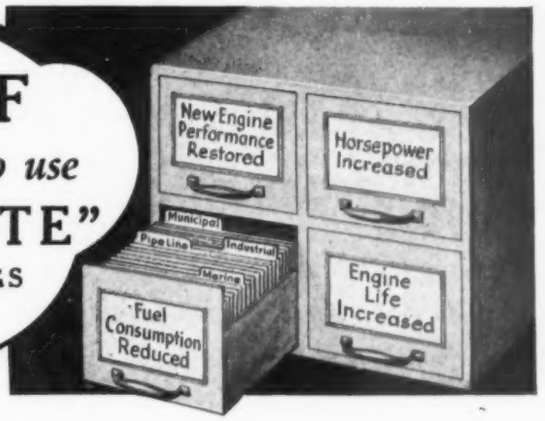
Chemical Analysis:

Total Carbon	3.25 - 3.40
Combined Carbon	.50 - .60
Sulphur	.12 Maximum
Phosphorus	.20 - .30
Manganese	.70 - .90
Silicon	2.00 - 2.25
Molybdenum	.30 - .40

Physical Analysis:

Tensile Strength	35,000 Lb. per sq. in.
Transverse Strength	4,400 Lb. per sq. in. on 12-in. centers
Deflection	.24-in.
Brinell Hardness	196-207 (3000 kg. load)

PROOF
that it pays to use
"COOKTITE"
PISTON RINGS



"Sealing Pressures Since 1888"

COMPARATIVE OPERATING DATA on internal combustion engine performance before and after installing COOKTITES have been supplied to us by a host of enthusiastic users. These records prove that COOKTITES are directly responsible for **increased horsepower — restoring new engine performance after cylinders become worn — higher fuel economy and increased engine life. Obtain these economies by specifying COOKTITES on your next order.**

WRITE for brochure containing complete details and approved application recommendations. For data pertinent to your particular engine, give make, type, serial number — also, if possible, cylinder wear and present K.W.H. per gallon of fuel.

● Cooktites seal both Cylinder and Groove

Blow-by through the joints in ordinary rings | *Cooktite Cylinder Seal* | *Cooktite Groove Seal* | *Cooktite has full depth radial strength*

C. LEE COOK MANUFACTURING CO.
INCORPORATED
LOUISVILLE, KY.
New York Cleveland Los Angeles Baltimore Chicago Tulsa New Orleans San Francisco

The heat treatment for hardened molybdenum cast-iron liners is as follows:

1. Stress relieved at 1000 deg. fahrenheit.
2. Quenched in oil at 1550 to 1575 deg. fahrenheit.
3. Drawn at 800 deg. fahrenheit.

The liners heat-treated in this manner increase the hardness from 196-207 Brinell in the as-cast, stress-relieved condition, to 337-377 Brinell. This results in a liner insuring much longer life and greater abrasion resistance, as well as increased corrosion resistance.

In order to increase the hardness even more, a great deal of experimenting is being done at the present time by the Axelson Manufacturing Company on NITRICASTIRON liners. The surface hardness of this material is from 850 to 1000 Brinell. This process consists of the injection of nitrogen into the surface of the material and producing a case of from .008 in. to .012 in. in thickness. This is accomplished by heating the liners to 950 deg. fahr. for 60 to 90 hours in the presence of anhydrous ammonia. This process does not require quenching; consequently there is practically no distorting and no scaling.

These liners are made from SAE 4615 alloy steel, which has corrosion resisting properties to a limited degree, and when carburized results in a very hard and abrasion-resisting liner.

Following is the heat treatment for these lines—the carburizing being done in a Leeds and Northrup gas-carburizing furnace with automatic temperature control: They are carburized for six hours at 1660 deg. fahrenheit. The heat is then shut off, and when the temperature drops to 1500 deg. fahr. they are removed from the furnace and immediately quenched in oil. This process insures the most uniform liner possible without danger of scaling or decarburizing of the surface. The resulting hardness is from 650 to 700 Brinell.

The same care and precautions in the machining and manufacturing of these liners are as necessary as the selection of materials and exactness in heat-treatment.

Patent Notice

Inasmuch as oil geologists and engineers are becoming increasingly familiar with the theory and scope of *Electrical Resistivity and Porosity Measurements,* and as well surveys of this type are being widely adopted as a regular procedure supplementing oil exploration and exploitation,

SCHLUMBERGER WELL SURVEYING CORPORATION

desires hereby to bring to the attention of the oil producers that it is operating under the protection of the following patents:

U. S. Patent No. 1,819,923
U. S. Patent No. 1,894,328
U. S. Patent No. 1,913,293
U. S. Patent No. 1,970,342

which cover the technique now in use, as evidenced particularly by the following claims:

"Patent 1,819,923 — Claim 1.
"An electrical process for determining the nature of the geological formations traversed by drill holes and which consists in measuring the electrical specific resistivity of the formations encountered at different depths inside the drill hole, where said hole contains water."

"Patent 1,913,293 — Claim 1.
"An electrical process for the geological investigation of the porous strata traversed by a drill hole, consisting in filling the hole with water or mud, and measuring in this fluid at various depths, in the uncased part of the hole the differences of potential which spontaneously take place at the contact between the porous strata and said fluid."

"Patent 1,970,342 — Claim 1.
"The method of determining the degree of salinity of the water contained in a porous stratum encountered by a bore hole, which consists in measuring in a mud of a given salinity filling the bore hole the electromotive force of the concentration element constituted by the water in the stratum, the mud in the bore hole and the surrounding rocks, and then repeating the said measurements with a mud of a different salinity in the bore hole."

Schlumberger Well Surveying Corporation is a firm of consulting engineers **completely independent of any oil company or operator.** It is endeavoring to make its services available in all important oil fields in the United States. The continued co-operation and patronage of its clients is respectfully solicited.

Schlumberger Well Surveying Corporation
920 ESPERSON BUILDING
HOUSTON, TEXAS

California Branch
517 Jergins Trust Building
LONG BEACH, CALIFORNIA

Oklahoma Branch
1315 Broadway Place
OKLAHOMA CITY, OKLA.

H. John Eastman, Drilling Expert, Leaves for Six Months Abroad

H. John Eastman, president Eastman Oil Well Survey Company, Eastman Oil Tool Company, Eastman Instrument Company of Long Beach, California, and the Eastman Oil Well Survey Company of Oklahoma, left recently for Texas, where he was joined by Wm. G. James, vice-president of the Eastman Oil Well Survey Company of Houston, Texas. Messrs. Eastman and James will embark on the S. S. Bremen, from New York City for a six months' trip abroad. The two men will go to Rumania, Burmah, Germany, France, and England, and will demonstrate directional drilling in the Rumania and Burmah fields. Eastman is chairman of the Eastman Oil Well Survey Company of Houston, Texas.

Macwhyte Wire Rope Stocked at Fort Worth

The Macwhyte Company, Kenosha, Wisconsin, has announced that, effective at once, a large stock of Macwhyte wire rope will be carried in Fort Worth at the Texas and Pacific terminal warehouse. Stocks will include wire lines for the oil fields, wire rope for elevators, quarries, steam shovels, cranes, excavators, and general hoisting. Lee Caldwell is district representative and L. A. Hines is being transferred from the Kenosha office to Fort Worth as local Macwhyte representative.

Petroleum Engineering Department at Texas A. & M. Has Had Rapid Growth

From the smallest to the largest engineering section in the college, and the largest department of its kind in point of undergraduate students of any institution in the country, is the six-year record of the department of petroleum production engineering at Texas A. & M. College, College Station, Texas.

This department, established at Texas A. & M. in 1929, has 285 undergraduate students, five more than the total number for the mechanical engineering department, the next largest engineering section at Texas A. & M.

Undergraduate enrollment figures for petroleum engineering students at some of the other leading colleges and universities of the country are: University of Oklahoma, 157; University of Texas, 135; University of Pittsburgh, 58; University of California, 45; Pennsylvania State College, 29; University of Southern California, 21; University of Kansas, 11.

Under the direction of Prof. Harold Vance, widely known petroleum engineer who became head of the department after years of experience in the oil fields, the department is broadening its scope as it is its student body. The course, according to Professor Vance, is designed to give the student not only the theoretical and research side of the petroleum production industry, but also the practical, business and legal angles of the work.

In addition to the regular classroom and laboratory work and field trips, the students this year are rigging up a complete miniature pumping set and also plan to do actual practice drilling. The general instruction also includes pipe line methods and management in addition to the production work.

Much of the equipment for the department has been donated by leading oil firms and oil well equipment manufacturers, including a small number of workable small-scale models in addition to full-sized equipment.

New Oil Refining Process Announced for Aviation Field

The new Clearosol Process for refining motor oils, recently announced by the Socony-Vacuum Oil Company, Inc., is extended to include aviation oils. This fact, with full details, was announced in the current issue of the company's publication, "R. P. M."

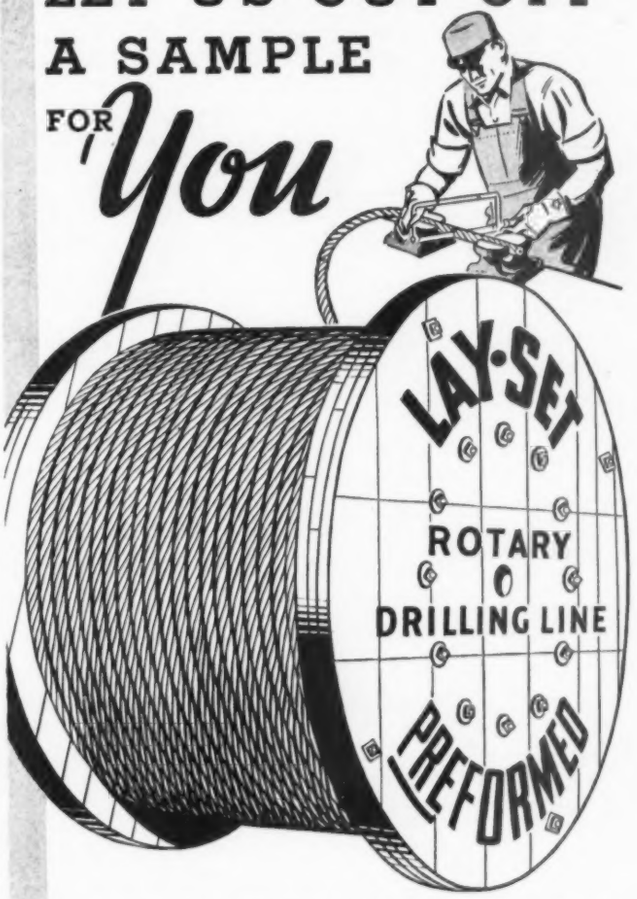
With this process it is now possible to market a product that will greatly reduce wear of moving parts, the Socony-Vacuum Oil Company states. It is also pointed out that the new process insures unusual freedom from ring gumming, excessive carbon deposits and sludge formation in the engine due to the oil.

Because of these facts, aviation engineers see in this new process in refining Aero Mobiloil, a decided step forward in the promoting of greater economy and safety of operation as well as in the assurance of better performance.

"This process," the R. P. M. story continues, "effects a purely physical separation of the valuable paraffinic hydrocarbons from the less valuable non-paraffinic compounds and undesirable asphaltic materials. The separation is obtained by mixing the lubricating oil stocks with two solvents.

"The valuable paraffinic constituents dissolve in one solvent and the undesirable elements dissolve in the other. Due to the difference in specific gravity, these two resulting solutions are easily separated."

LET US CUT OFF A SAMPLE FOR *You*



● A sample length of Lay-Set Preformed will do a better job of selling, all by itself, than could be done by a whole flock of salesmen. You can take it apart, strand from strand and wire from wire, then put it together again — exactly as you received it. By this simple test Lay-Set will prove how the preforming—

. . . does away with all internal stress; makes Lay-Set *resist* kinking; compels every wire and strand to carry its full load; makes Lay-Set much easier to handle and thereby cut down the time and cost of replacement, splicing, socketing. All of which will be proof in itself that Lay-Set Preformed Rotary Lines will last longer.

Send for a sample of Lay-Set Preformed Rotary Lines today. Write us — right now.

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In Business for Your Safety
District Offices: New York, Chicago, Philadelphia, Fort Worth, San Francisco, Pittsburgh, Denver Los Angeles, Birmingham, Tacoma

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LAY-SET *Preformed* ROTARY LINES

Rapid Advances Made in Automobile Engines

Remarkable advances have been made in the development of the automobile engine in the past nine years, it is shown by a study reported to the American Petroleum Institute by C. D. Hawley and Earl Bartholomew, of the engineering laboratories of the Ethyl Gasoline Corporation, owned jointly by General Motors Corporation and the Standard Oil Company of New Jersey.

Average power output has been increased 88 per cent. The hp. of the smaller, and by far the most numerous, cars is now two to four and one-half times the 1925 figures.

Increases in power, it is pointed out, must necessarily come from increases in one or more of the following: displacement, speed, brake mean effective pressure.

"The average engine now has 14 per cent greater displacement than in 1925, and there has been no change in this figure during the past two years," it is explained. "The automobile-engineering fraternity is convinced of the folly of a displacement race, and is concentrating its efforts on a better utilization of a given cylinder capacity and weight of metal.

"The average 1934 engine has a power-peaking speed 30 per cent higher than in 1925, and there is no indication that the limit has been reached. Because of the high torque requirement of the automobile engine over its entire speed range, it has not been possible to alter valve timing to favor the higher speeds; instead the better high-speed performance has resulted almost entirely from freer breathing and higher compression pressures, which also improve low-speed torque.

"Brake mean effective pressure at the power-peaking speed has increased 27 per cent. In other words, every cu. in. of engine delivers 27 per cent more power at a given speed than it did in 1925; and, at the same mixture ratio, there is a corresponding improvement in specific economy. Average compression ratios have gone up 30 per cent, and compression pressures at least 46 per cent.

"It is known that restricted breathing of the earlier engines produced a lower compression pressure at a given compression ratio and, consequently a lower volumetric efficiency. Higher compression ratios and improved volumetric efficiency are responsible for the higher brake mean effective pressure of the present automobile."

Ray L. Howes Joins Worthington

As a result of increased activity in its Diesel and gas engine lines, the Worthington Pump and Machinery Corporation of Harrison, New Jersey, has found it advisable further to amplify the supervision of business in these lines in its Eastern district, and to that end has created the Eastern Oil Power Division, under the field management of Ray L. Howes, with headquarters at its New York office, No. 2 Park Avenue, it is announced.

Howes is widely known in the Diesel engine world and has had extensive experience in its various fields of application. Through the corporation's field organization in the territories of the district offices of Boston, New York, Philadelphia, Washington, and Atlanta, Howes will have supervision of Diesel engine sales in those territories.

FAST — SAFE

Insures Making Faster Hole

FIG 1

FIG 2

The CAVINS

The unretouched illustrations above clearly demonstrate why The CAVINS is the fastest and best way to clean out a well. The tool retains sufficient pressure when coming out of the hole to dump the entire load automatically. (See the force of this pressure in Fig. 1.) When the tool is pulled out, spot it on the dumping key, give it half a turn with the wrench, and the load is shot out under pressure. (See Fig. 2.) It is not necessary for operator to be on same side as dumping port, or near it . . . an important safety feature.

Fig. 2. Shows a well from which 90 ft. of sand was cleaned out in 2½ hours, due to the unusual speed of The CAVINS. You simply run it in to bottom, trip, and pull-out. It loads and unloads automatically in just a few seconds. Write for Bulletin and performance data.

The CAVINS Company

2853 Cherry Avenue — *Cable Address:* "Cavins, Long Beach" — LONG BEACH, CALIF., U. S. A.

R. J. EICHE, *Foreign Representative*
Branches at: Taft, Bakersfield, Goleta and Santa Paula, Calif.

CAVINS CLEAN-OUT SERVICE: Oklahoma City, Okla., and McPherson, Kansas

CAVINS BAILER SERVICE: Houston and Kilgore, Texas, and Shreveport, La.

Armstrong Bros. Tool Company Purchases "Ideal Chain Tong" Line

Officials of the Armstrong Bros. Tool Company, Chicago, Illinois, have announced the purchase of the well-known line of "Ideal Chain Tongs" from the Carrier Engineering Corporation, Newark, New Jersey. The line has been obtained complete, including the name, inventory, etc. The feature of the "Ideal Chain Tong" is that the jaws are made with double-angle teeth, straight teeth for gripping pipe, and teeth cut at an angle for gripping fittings.

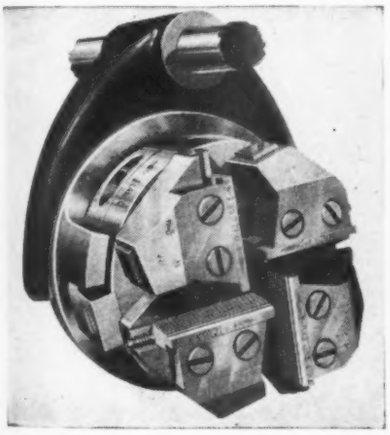
Booklet on "Flex-Set" Preformed Yellow Strand Wire Rope

The Broderick and Bascom Rope Company, St. Louis, Missouri, has issued a booklet on its "Flex-Set" preformed yellow strand wire rope. Information is given on the construction of the rope, its numerous applications, and its service record. A copy of the publication is obtainable free upon request to the manufacturer.

Landis Revolving Die Head with Taper Attachment

There recently has been placed on the market by the Landis Machine Company of Waynesboro, Pennsylvania, a revolving die head with taper attachment for producing tapered threads. This head is an adaptation of the ¾-in. Lanco head, but has a standard capacity up to 1¼-in. American tapered pipe threads with a maximum thread length of 1¼-inch. By using special oversize chaser holders, diameters up to 2¾-in. can be cut with a maximum thread length of 1⅛-inch. Any degree of taper can be provided up to 2-in. taper per ft. by using the proper operating ring and cam shoe. The head is suitable for application to practically any make of automatic chucking machine employing a revolving type of die head.

The taper cutting action is obtained through a cam that is integral with the



operating ring. Attached to the closing ring of the die head is a cam shoe machined to correspond to the operating cam. As the threading spindle moves forward the closing yoke on the die head contacts the usual adjustable stop nut on the stop bar on the machine just as the chasers begin to form the thread. At this point the forward travel of the operating ring is retarded while the die head itself continues to move forward to produce the thread. As the die head continues to move forward onto the work this construction causes the chasers to open gradually, thus generating a tapered thread. When the cam shoe has traveled the full length of the cam on the operating ring the die head automatically opens. Adjustment for thread length is obtained by properly setting the stop nut on the stop bar.

Since the forming and the finishing of the thread is done by the first few teeth on the chasers, cutting strains are no greater than would be required

USE SHAFFER Cellar Control Gates for controlling your wells. One Gate with complete shut-off rams provides protection when drillpipe is out of the hole and a second Gate with drillpipe rams provides for closing around drillpipe when in the hole.

These Gates may be closed while the well is spouting wildly and can be easily opened under the accumulated high pressure if necessity demands.

Shaffer Universal Joint Connections give remote control from outside the derrick or power control can be furnished by means of a Pelton Wheel.

Specialists in HIGH PRESSURE EQUIPMENT

SHAFFER TOOL WORKS

Brea, California Houston, Texas

EXPORT — OIL WELL SUPPLY COMPANY

We build valves for all kinds of services at all pressures. We also have a thorough knowledge of oil and gas requirements. This insures correct design and the type of performance you want. Let us quote you on your next special job.

The LUDLOW VALVE MFG. CO.
TROY, NEW YORK

HOTEL BILTMORE

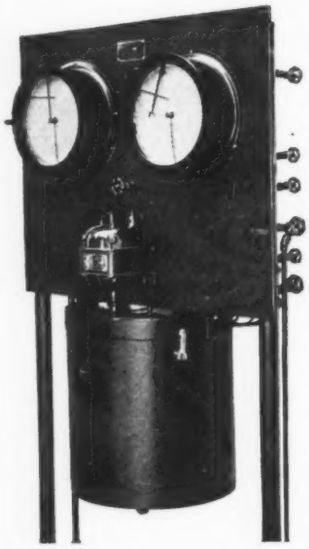
. . . in Oklahoma City, combines all the features of the modern metropolitan hotel at its best. All rooms have three-channel radio and every other possible convenience.

You'll find the food and service in both the Main Restaurant and Coffee Shop in keeping with Hotel Biltmore standards. The Hotel's downtown location makes theatres and shops easily available.

Room rates start at $2.50

for cutting a straight thread of corresponding diameter. Furthermore, the length of a tapered thread which can be cut is not limited to the width of the chasers, but is controlled only by the length of the cam travel. The result of this free cutting action is a better finish on the thread, as well as a longer life for the chasers, the manufacturers state.

TAG Announces New Vapor Pressure Recorder



The C. J. Tagliabue Manufacturing Company, Park and Nostrand Avenues, Brooklyn, New York, has obtained the exclusive world-wide manufacturing and sales rights for a new Vapor Pressure Recorder. This device is a development of Idustrial Engineers, Inc., of Los Angeles, California, under the Kallam patents and will be known as the TAG-Industrial Engineers Continuous Vapor Pressure Recorder.

Now, instead of the long-delayed results obtained from the Reid laboratory test, it is possible with this recorder to have a continuous record of vapor pressure instantly available, the manufacturers state. Since vapor pressure is one of the most important single factors in the manufacture, blending and shipping of light petroleum products, the utility of this device should be great.

The instrument has been placed on the market after five years of experimental and development work and several years of plant service.

It is fully described in bulletin No. 1115, which the company will be glad to send upon request.

Brown Instrument and Minneapolis-Honeywell Regulator Open Atlanta Office

The Brown Instrument Company, Philadelphia, Pennsylvania, manufacturers of instruments and controls, and the Minneapolis-Honeywell Regulator Company, Minneapolis, Minnesota, manufacturers of control systems and regulators, have opened a joint office at 303 - the 101 Marietta Street Building, Atlanta, Georgia, to serve the Southeast.

Wesley R. Moore, for a number of years district manager of Brown Instrument Company, is manager in charge, with Leon L. Kuempel, sales engineer, Charles A. Kitzinger, service engineer, and J. A. Crawley, office manager.

SPERRY-SUN WELL SURVEYING CO.
1608 WALNUT STREET, PHILADELPHIA, PA.
HOUSTON, TEXAS. TULSA, OKLAHOMA
AND LOS ANGELES, CALIFORNIA

SURWEL (Gyroscopic) H-K (Open Hole) SYFO (Ink Bottle)

UNDERGROUND WELL SURVEYING SERVICE

New Diesel Generator Set Introduced

Joint announcement is made by the Harnischfeger Corporation of Milwaukee, Wisconsin, and the Caterpillar Tractor Company, of Peoria, Illinois, of a co-operative arrangement for building Diesel-powered generator sets that will bear the name plate, "Harnischfeger-Caterpillar."

Offered in capacities ranging from 35 to 60 kw., these sets fill all a.c. and d.c. requirements for service in mines, quarries, construction camps, municipalities, etc. Generators are of the single-bearing type, directly connected by link coupling to the Diesel engine and mounted on a substantial cast-iron base.

The standard unit will include the engine with all auxiliaries, radiator cooling system, starting engine, auxiliary fuel pump, engine controls to provide proper speed setting and close governing, coupling between engine and generator, flywheel and coupling guard and the generator mounted on the unit base.

The electrical generator units, manufactured at Milwaukee, are shipped to the Caterpillar plant at Peoria for final assembly. Production is already under way.

Walter H. Wiewel New Manager of Tubular Sales for Jones & Laughlin

Walter H. Wiewel was appointed manager of sales, tubular products, for the Jones & Laughlin Steel Corporation, effective June 1, to fill the vacancy recently created by the death of F. D. Grunder.

Wiewel, since 1932, has been manager of tube sales for the Timken Steel and Tube Company of Canton, Ohio. He was first employed in 1910 by the Cambria Steel Company in their Cleveland office. In 1914 he became associated with the United Steel Company, Canton, Ohio, and in 1918 was appointed assistant general manager of sales of the successor company, the United Alloy Steel Corporation.

He was appointed manager of the New York district office of the Standard Seamless Tube Company in 1925 and later joined the Timken Steel & Tube Company staff.

L. S. Allen Goes with Mid-Continent Supply; J. A. Daugherty to Tulsa

L. S. "Spider" Allen, for many years district manager for the Naylor Pipe Company, Chicago, Illinois, has accepted a position as district tubular manager for the Mid-Continent Supply Company, with headquarters at Tulsa, Oklahoma.

J. A. Daugherty, vice-president, Mid-Continent Supply Company, Houston, Texas, is being transferred to Tulsa, Oklahoma, at which point the company is enlarging its offices and expanding its organization.

Correction

In the second paragraph on p. 56 of the May issue, the eighth and ninth lines should read: "Using a gas input of 500,000 cu. ft. per day, and." Referring to the sketch, Fig. 8 on the same page, the gas release line indicated on the oil and gas separator should read: "Gas Released to Atmosphere Through Meter."

B PRODUCTS for pumping wells

The KEY to LOWER LIFTING COSTS

CORRECTLY DESIGNED · · ECONOMICALLY PRODUCED

REASONABLY PRICED

B-M-W NEILSON SAFETY SUCKER ROD HOOKS

No. 25 has 25,000 Safe Working Load; No. 40 has 40,000 Safe Working Load. Free swiveling . . . simple, rugged latch operated with thumb or finger. Molybdenum Alloy Steel endows this unit with surplus strength. A trial is invited. Ask your Supply Store.

POSITIVE LOCKING TYPE

BRADFORD MOTOR WORKS INC.

OIL WELL SUPPLIES

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in the most modern service

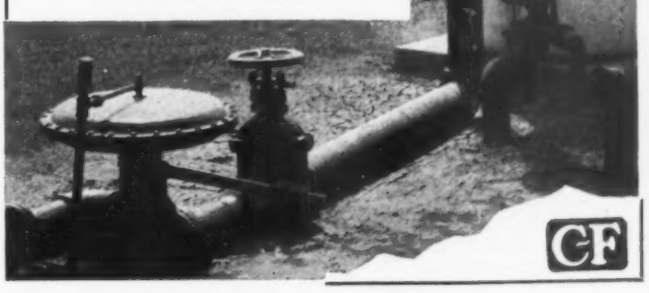
WHERE the most advanced methods and the most highly specialized equipment are used, and where the most precise and unfailing control of pressures is required, in any department of industry, Chaplin-Fulton Regulators will be found at work. For more than forty years, they have been used with success and satisfaction, new design and new technique of manufacture being always adjusted to meet new conditions or new demands. So now more than ever they are recognized as standard equipment.

Correspondence regarding any special need of pressure control will be given careful attention.

The Regulators here seen are in operation in a flowing plant of an active Oklahoma oil field

THE CHAPLIN-FULTON Manufacturing Company

28-40 Penn Ave., Pittsburgh, Pa.



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116 New Montgomery St. · San Francisco, Calif.

Progress in Pipe Lining

By

OWEN C. JONES

The Linde Air Products Company

Advantages of Multi-Flame Lindewelding are greatest if there is sound organization of crews

IT was only five brief years ago that the Lindeweld process for welding pipe lines was introduced. At that time many interesting claims for increased speed and efficiency were recounted. The developments of the past 18 months have far surpassed such early claims.

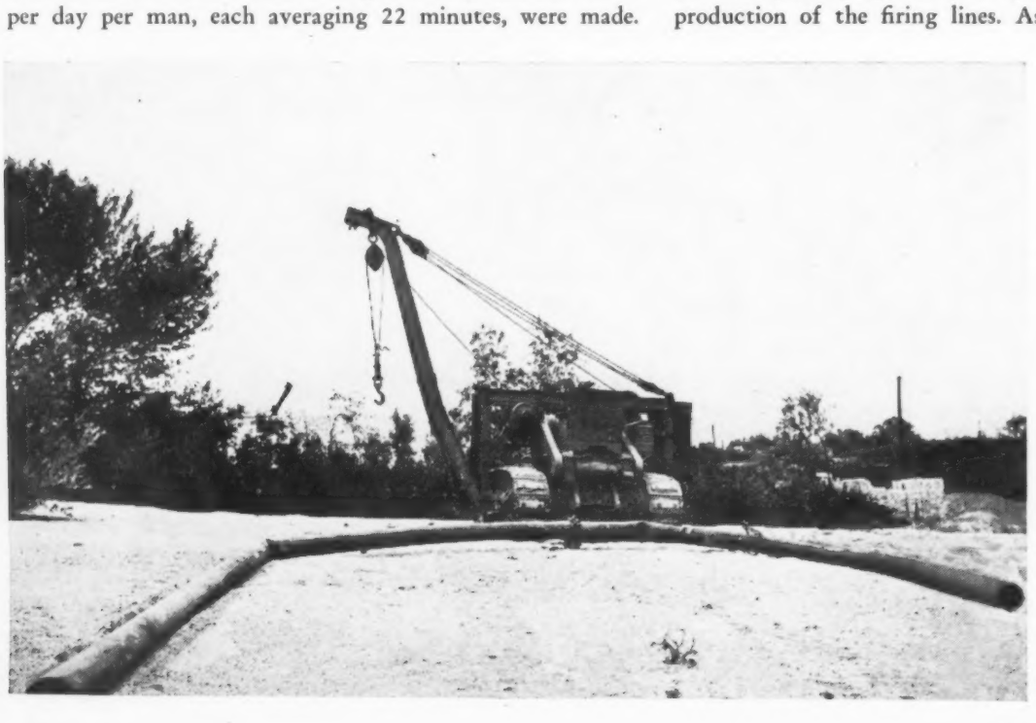
Prominent among these developments was the multi-flame blowpipe. Since its introduction well over 100,000 welds have been made with it resulting in savings of more than 25 per cent in rod and gas consumption and more than 30 per cent in welding time over older methods. The speed, economy, and the consistent high strength and quality of the welds produced are well known. With the new production speeds made possible by advanced technique, special welding rod and multi-flame head, operating companies have focused more attention on organization.

They have realized that only by efficient organization can the maximum advantages of this process be attained. A comparison of a few typical jobs illustrates this clearly.

In one instance in the Mid-Continent section where six miles of 12-in. 16-in., and 18-in. pipe were laid, interesting comparisons between the use of the single-flame and the multi-flame method were possible. For several days, on the firing line, two operators used the single-flame blowpipe and two the multi-flame. With the single-flame method 24 welds per day per man, each averaging 22 minutes, were made. With the multi-flame blowpipe 30 welds per day per man, each averaging 12 minutes, were made. These results are interesting because the pipe was old, and welded without any special bevel preparation.

On another job, 24½ miles of new, 8-in., ¼-in. wall, 40-ft. pipe was put down. This was machine-beveled. The six operators, using the single-flame method, averaged 50 welds each per day over level right-of-way, and the average time per weld was eight minutes. Thirty miles of 6-in. were laid on the same line. For this, multi-flame blowpipes were used. Of the 30 miles, 13 were laid with pipe beveled to 45 deg. (too wide). It took 5½ min. for each weld. On the other 17 miles, however, the pipe was correctly beveled. This boosted production to 68 welds per day with a maximum of 75. At this end of the job the firing line gang was held up for lack of pipe and the line-up gang was continually hard-pressed by the six operators. For this work the average time per weld was 4½ minutes.

Following these jobs a number of contracts were made for relooping through Oklahoma and Kansas. It is unessential to detail these, but it should be noted that the use of the multi-flame blowpipe was just being developed, and the operating officials were primarily concerned with smoothing out and speeding up the crew operations to meet increasing production of the firing lines. As it was, on one loop an



Joints given a severe test. Old drill pipe of 100,000 lb. per sq. in. tensile strength, 6-in. dia., 0.333-in. wall thickness, was welded by the multi-flame process and then by securing the 60-ft. section (3 lengths) to a bridge column, was bent cold 180 deg. by means of a tractor. The test was so arranged to give the welds the greatest strain. There was no sign of collapse at the welds

A welder using the multi-flame welding method

average speed of 33, with maximum of 36 welds each per day, was made on new 12-in., 11/32-in. wall pipe. On another loop of 40 miles of 10-in., 11/32-in. wall pipe, 39 welds per day each were completed.

Another job, begun later in the season, shows what ideal conditions can produce. A line of 6-in., ¼-in. wall pipe was to be laid extending from Burrton to Hutchinson, Kansas. Right-of-way conditions were level, but quite sandy, so that a certain amount of time was lost in lining-up the pipe. The average production for this job was 73 welds per day each and during the course of the last day the welders were averaging 11 welds each per hour, or 88 per day. Incidentally the last 12 miles of line was completed in 33 working hours.

There is one significant feature in connection with much of the recent work. It is the fact that a large quantity of pipe has been dug up, cleaned, prepared for welding by flame beveling, and relaid again. There have been just two factors that have made this type of work practical and economical: the possibility of both cutting up the line and beveling the edges in one operation by means of the special pipe-trimming and beveling machine; and the availability of the multi-flame welding method with which it is possible to make good welds, fast, on old pipe. For instance, an 8-in. line was laid in February of this year from the Fitts pool near Ada, Oklahoma, to Francis, Oklahoma, a matter of 25 miles. Because of code restrictions, the operators were allowed to work only 4½ eight-hour days per week; however, for ten days, the six operators averaged 54 welds per man on 32-lb. second-hand, flame-beveled pipe.

The fastest time recorded for making a single 8-in. diameter weld on this line was 4½ minutes. The greatest number of welds by six men in one day was 361. The greatest number of welds per acetylene generator (two men working from each generator) was 122, or 61 welds per man per day. This firing line consistently averaged about 8000 ft. daily with pipe joints in 20-ft. random lengths.

One of the jobs of current interest is the 250-mile, 6-in. gasoline line laid from Enid, Oklahoma, to Superior, Nebraska. The reports on this job have been extremely interesting; incidentally, it is an example of what can be done with efficient organization of the crew. Every effort was made to consolidate the efforts of each man and each gang. The firing line got well ahead of the rest of the crew. The operators were averaging 75, with a maximum of 87 welds each per day and it is reported that one day both the north and south end gangs welded some 30,000 ft. of pipe.

As far as any conclusions can be drawn, it would seem that the past year's work has pointed strongly to the need for organizing to the last detail in order to attain the greatest production and likewise maximum economy. The year's activities have demonstrated that the welding process, the materials, and skill are available. By coördination of the proper sort these can produce real results.

L. J. Pundt Division Manager at Houston for S. M. Jones Company

The S. M. Jones Company, Toledo, Ohio, announces the appointment of L. J. Pundt as division manager in charge of a new Houston division composed of the Eastern part of the state of Texas, Southwestern section of Arkansas, and the state of Louisiana. This change was effective June 1st.

Pundt has been connected with The S. M. Jones Company for the last 11 years, having previously been in charge of their Houston district, and is thoroughly experienced in pumping problems.

Oil Well Ladder

An intermittent air-lift apparatus that operates on the displacement principle is a new deep well pumping device being developed by one manufacturer. This apparatus has been designated as the OIL WELL LADDER. Although it is still in the development stage, the device has some attractive principles that may be applied to the lifting of oil from deep wells, especially in crooked holes. The apparatus is being developed by the Key Company, P. O. Box 494, East St. Louis, Illinois, to whom requests for information regarding it should be addressed.

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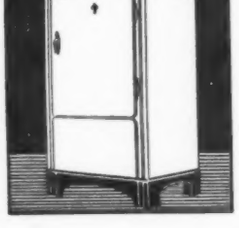

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Wacker Appointed Assistant General Sales Manager of C. J. Tagliabue Mfg. Co.

The C. J. Tagliabue Manufacturing Company, Brooklyn, New York, manufacturers of temperature, pressure, flow, humidity, time, and level instruments, announces the appointment of E. D. Wacker as assistant general sales manager.

Wacker has been with the company for 11 years, part of the time as manager of the Pittsburgh territory and, more recently, as division sales manager in charge of "snapon controller" sales for domestic refrigerators.

A considerable portion of his time will be spent in the field contacting sales representatives, as well as jobbers.

The company also announces that the sales of the Snapon Controller Division will be in charge of R. A. Skinner.

New Type Pipe Coupling Simplifies Joint Making

Several unusual features are incorporated in a new, self-contained pipe joint announced by the S. R. Dresser Manufacturing Company of Bradford, Pennsylvania. To make a connection with this new joint, called the Dresser Style 65 Compression Coupling, nothing is needed, according to the manufacturer, except the pipe, the joint itself, and an ordinary wrench. Plain end pipe is used, no special preparation of the pipe ends—such as threading, grooving, or flaring—being necessary. Making the joint simply involves inserting the pipe ends into the coupling (which comes assembled) and then tightening two threaded octagonal nuts with a wrench—the whole operation taking only a few seconds.

The resulting joint is not only permanently tight, but absorbs normal vibration, expansion and contraction movements, and permits deflections of the pipe in the joint, it is stated.

This flexibility plus permanent tightness, according to the manufacturer's announcement, is made possible by two resilient gaskets that encircle the pipe ends—one gasket around each end. As the nuts are tightened, these gaskets are compressed tightly around the pipe, gripping it with tremendous force and giving a positive seal. The principle involved is essentially the same as that used in other Dresser couplings for the past 50 years.

Other features are these: the pipe need not be cut to exact lengths; joint-making in cramped quarters is simplified; repairs on old lines can be quickly and easily made; and the joint is suitable for exposed lines because of its compact appearance.

Dresser Compression Couplings, Style 65, are supplied in standard steel pipe sizes from ⅜-in I.D. to 2-in. I.D., inclusive, black or galvanized. The manufacturers recommend them for all types of services. The gaskets, which are provided with a flexible, metallic, patented armor in the tip, are suitable for temperatures up to 200 deg. fahrenheit. The manufacturers believe that this new coupling will have a wide application on both inside and outside piping on gas, water, oil, air, chemical and industrial lines under high and low pressures.

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